

CA2ALEN752
88R88-08
Vault 19

REPORT #
RRTAC 88-8

Alberta Forest Service Watershed Management Field And Laboratory Methods



Heritage Fund



LAND CONSERVATION AND
RECLAMATION COUNCIL
Reclamation Research
Technical Advisory Committee

ALBERTA FOREST SERVICE WATERSHED MANAGEMENT

FIELD AND LABORATORY METHODS

Prepared by

A.M.K. Nip and R.A. Hursey

for

The Alberta Forest Service

Forest Research Branch

and published by

THE ALBERTA LAND CONSERVATION AND RECLAMATION COUNCIL

(Reclamation Research Technical Advisory Committee)

1988



DISCLAIMER

The recommendations and conclusions in this report are those of the author and not of the Alberta Government or its representatives.

This report is intended to provide government and industry staff with up-to-date technical information to assist in the preparation and review of Development and Reclamation Approvals, and development of guidelines and operating procedures. This report is also available to the public so that interested individuals similarly have access to the most current information on land reclamation topics.

ALBERTA'S RECLAMATION RESEARCH PROGRAM

Regulating surface disturbances in Alberta is the responsibility of the Land Conservation and Reclamation Council. The Council executive consists of a Chairman from Alberta Environment and two deputy chairmen from Alberta Forestry, Lands and Wildlife. The Council oversees a reclamation research program, established in 1978, to identify the most efficient methods for achieving acceptable reclamation in the province. Funding for the research program is provided by Alberta's Heritage Savings Trust Fund.

To assist with development and administration of the research program, the Council appointed the interdepartmental Reclamation Research Technical Advisory Committee (RRTAC). The Committee consists of eight members representing the Alberta Departments of Agriculture, Forestry, Lands and Wildlife, Environment, and the Alberta Research Council. The Committee updates research priorities, reviews solicited and unsolicited research proposals, organizes workshops, and otherwise acts as the coordinating body for reclamation research in Alberta.

Additional information on the Reclamation Research Program may be obtained by contacting:

Chris Powter, Research Manager
Reclamation Research Technical Advisory Committee
Alberta Environment
3rd Floor, Oxbridge Place
9820 - 106 Street
Edmonton, Alberta T5K 2J6

(403) 427-4147

This report may be cited as:

Nip, A.M.K. and R.A. Hursey, 1988. Alberta Forest Service Watershed Management Field and Laboratory Methods. Prepared for the Alberta Forest Research Branch and published as Alberta Land Conservation and Reclamation Council Report #RRTAC 88-8. Four sections, various pagings.

Additional copies may be obtained from:

Publication Services
Queen's Printer
11510 Kingsway Avenue
Edmonton, Alberta T5G 2Y5

(403) 427-4925

RECLAMATION RESEARCH REPORTS

- ** 1. RRTAC 80-3: The Role of Organic Compounds in Salinization of Plains Coal Mining Sites. N.S.C. Cameron et al. 46 pp.

DESCRIPTION: This is a literature review of the chemistry of sodic mine spoil and the changes expected to occur in groundwater.

- ** 2. RRTAC 80-4: Proceedings: Workshop on Reconstruction of Forest Soils in Reclamation. P.F. Ziemkiewicz, S.K. Takyi, and H.F. Regier. 160 pp.

DESCRIPTION: Experts in the field of forestry and forest soils report on research relevant to forest soil reconstruction and discuss the most effective means of restoring forestry capability of mined lands.

- N/A 3. RRTAC 80-5: Manual of Plant Species Suitability for Reclamation in Alberta. L.E. Watson, R.W. Parker, and D.F. Polster. 2 vols, 541 pp.

DESCRIPTION: Forty-three grass, fourteen forb, and thirty-four shrub and tree species are assessed in terms of their suitability for use in reclamation. Range maps, growth habit, propagation, tolerance, and availability information are provided.

- N/A 4. RRTAC 81-2: 1980 Survey of Reclamation Activities in Alberta. D.G. Walker and R.L. Rothwell. 76 pp.

DESCRIPTION: This survey is an update of a report prepared in 1976 on reclamation activities in Alberta, and includes research and operational reclamation, locations, personnel, etc.

- N/A 5. RRTAC 81-3: Proceedings: Workshop on Coal Ash and Reclamation. P.F. Ziemkiewicz, R. Stein, R. Leitch, and G. Lutwick. 253 pp.

DESCRIPTION: Presents nine technical papers on the chemical, physical, and engineering properties of Alberta fly and bottom ashes, revegetation of ash disposal sites, and use of ash as a soil amendment. Workshop discussions and summaries are also included.

- N/A 6. RRTAC 82-1: Land Surface Reclamation: An International Bibliography. H.P. Sims and C.B. Powter. 2 vols, 292 pp.

DESCRIPTION: Literature to 1980 pertinent to reclamation in Alberta is listed in Vol. 1 and is also on the University of Alberta computing system (in a SPIRES database called RECLAIM). Vol. 2 comprises the keyword index and computer access manual.

- N/A 7. RRTAC 82-2: A Bibliography of Baseline Studies in Alberta: Soils, Geology, Hydrology, and Groundwater. C.B. Powter and H.P. Sims. 97 pp.

DESCRIPTION: This bibliography provides baseline information for persons involved in reclamation research or in the preparation of environmental impact assessments. Materials, up to date as of December 1981, are available in the Alberta Environment Library.

- N/A 8. RRTAC 83-1: Soil Reconstruction Design for Reclamation of Oil Sand Tailings. Monenco Consultants Ltd. 185 pp.

DESCRIPTION: Volumes of peat and clay required to amend oil sand tailings were estimated based on existing literature. Separate soil prescriptions were made for spruce, jack pine, and herbaceous cover types. The estimates form the basis of field trials.

- N/A 9. RRTAC 83-3: Evaluation of Pipeline Reclamation Practices on Agricultural Lands in Alberta. Hardy Associates (1978) Ltd. 205 pp.

DESCRIPTION: Available information on pipeline reclamation practices was reviewed. A field survey was then conducted to determine the effects of pipe size, age, soil type, construction method, etc. on resulting crop production.

- N/A 10. RRTAC 83-4: Proceedings: Effects of Coal Mining on Eastern Slopes Hydrology. P.F. Ziemkiewicz. 123 pp.

DESCRIPTION: Technical papers are presented dealing with the impacts of mining on mountain watersheds, their flow characteristics, and resulting water quality. Mitigative measures and priorities were also discussed.

- N/A 11. RRTAC 83-5: Woody Plant Establishment and Management for Oil Sands Mine Reclamation. Techman Engineering Ltd. 124 pp.

DESCRIPTION: This is a review and analysis of information on planting stock quality, rearing techniques, site preparation, planting, and procedures necessary to ensure survival of trees and shrubs in oil sand reclamation.

- *** 12. RRTAC 84-1: Land Surface Reclamation: A Review of the International Literature. H.P. Sims, C.B. Powter, and J.A. Campbell. 2 vols, 1549 pp.

DESCRIPTION: Nearly all topics of interest to reclamationists including mining methods, soil amendments, revegetation, propagation and toxic materials are reviewed in light of the international literature.

- ** 13. RRTAC 84-2: Propagation Study: Use of Trees and Shrubs for Oil Sand Reclamation. Techman Engineering Ltd. 58 pp.

DESCRIPTION: This report evaluates and summarizes all available published and unpublished information on large-scale propagation methods for shrubs and trees to be used in oil sand reclamation.

- * 14. RRTAC 84-3: Reclamation Research Annual Report - 1983. P.F. Ziemkiewicz. 42 pp.

DESCRIPTION: This report details the Reclamation Research Program indicating priorities, descriptions of each research project, researchers, results, and expenditures.

- ** 15. RRTAC 84-4: Soil Microbiology in Land Reclamation. D. Parkinson, R.M. Danielson, C. Griffiths, S. Visser, and J.C. Zak. 2 vols, 676 pp.

DESCRIPTION: This is a collection of five reports dealing with re-establishment of fungal decomposers and mycorrhizal symbionts in various amended spoil types.

- ** 16. RRTAC 85-1: Proceedings: Revegetation Methods for Alberta's Mountains and Foothills. P.F. Ziemkiewicz. 416 pp.

DESCRIPTION: Results of long-term experiments and field experience on species selection, fertilization, reforestation, topsoiling, shrub propagation and establishment are presented.

- * 17. RRTAC 85-2: Reclamation Research Annual Report - 1984.
P.F. Ziemkiewicz. 29 pp.

DESCRIPTION: This report details the Reclamation Research Program indicating priorities, descriptions of each research project, researchers, results, and expenditures.

- ** 18. RRTAC 86-1: A Critical Analysis of Settling Pond Design and Alternative Technologies. A. Somani. 372 pp.

DESCRIPTION: The report examines the critical issue of settling pond design, and sizing and alternative technologies. The study was co-funded with The Coal Association of Canada.

- ** 19. RRTAC 86-2: Characterization and Variability of Soil Reconstructed after Surface Mining in Central Alberta. T.M. Macyk. 146 pp.

DESCRIPTION: Reconstructed soils representing different materials handling and replacement techniques were characterized, and variability in chemical and physical properties was assessed. The data obtained indicate that reconstructed soil properties are determined largely by parent material characteristics and further tempered by materials handling procedures. Mining tends to create a relatively homogeneous soil landscape in contrast to the mixture of diverse soils found before mining.

- * 20. RRTAC 86-3: Generalized Procedures for Assessing Post-Mining Groundwater Supply Potential in the Plains of Alberta - Plains Hydrology and Reclamation Project. M.R. Trudell and S.R. Moran. 30 pp.

DESCRIPTION: In the Plains region of Alberta, the surface mining of coal generally occurs in rural, agricultural areas in which domestic water supply requirements are met almost entirely by groundwater. Consequently, an important aspect of the capability of reclaimed lands to satisfy the needs of a residential component is the post-mining availability of groundwater. This report proposes a sequence of steps or procedures to identify and characterize potential post-mining aquifers.

- ** 21. RRTAC 86-4: Geology of the Battle River Site: Plains Hydrology and Reclamation Project. A. Maslowski-Schutz, R. Li, M. Fenton and S.R. Moran. 86 pp.

DESCRIPTION: This report summarizes the geological setting of the Battle River study site. It is designed to provide a general understanding of geological conditions adequate to establish a framework for hydrogeological and general reclamation studies. The report is not intended to be a detailed synthesis such as would be required for mine planning purposes.

- ** 22. RRTAC 86-5: Chemical and Mineralogical Properties of Overburden: Plains Hydrology and Reclamation Project. A. Maslowski-Schutz. 71 pp.

DESCRIPTION: This report describes the physical and mineralogical properties of overburden materials in an effort to identify individual beds within the bedrock overburden that might be significantly different in terms of reclamation potential.

- * 23. RRTAC 86-6: Post-Mining Groundwater Supply at the Battle River Site: Plains Hydrology and Reclamation Project. M.R. Trudell, G.J. Sterenberg and S.R. Moran. 49 pp.

DESCRIPTION: The report deals with the availability of water supply in or beneath cast overburden to support post-mining land use, including both quantity and quality considerations. The study area is in the Battle River Mining area in east-central Alberta

- * 24. RRTAC 86-7: Post-Mining Groundwater Supply at the Highvale Site: Plains Hydrology and Reclamation Project. M.R. Trudell. 25 pp.

DESCRIPTION: This report evaluates the availability of water supply in or beneath cast overburden to support post-mining land use, including both quantity and quality considerations. The study area is the Highvale mining area in west-central Alberta.

- * 25. RRTAC 86-8: Reclamation Research Annual Report - 1985. P.F. Ziemkiewicz. 54 pp.

DESCRIPTION: This report details the Reclamation Research Program indicating priorities, descriptions of each research project, researchers, results, and expenditures.

- ** 26. RRTAC 86-9: Wildlife Habitat Requirements and Reclamation Techniques for the Mountains and Foothills of Alberta. J.E. Green, R.E. Salter and D.G. Walker. 285 pp.

DESCRIPTION: This report presents a review of relevant North American literature on wildlife habitats in mountain and foothills biomes, reclamation techniques, potential problems in wildlife habitat reclamation, and potential habitat assessment methodologies. Four biomes (Alpine, Subalpine, Montane, and Boreal Uplands) and 10 key wildlife species (snowshoe hare, beaver, muskrat, elk, moose, caribou, mountain goat, bighorn sheep, spruce grouse, and white-tailed ptarmigan) are discussed. The study was co-funded with The Coal Association of Canada.

- ** 27. RRTAC 87-1: Disposal of Drilling Wastes. L.A. Leskiw, E. Reinl-Dwyer, T.L. Dabrowski, B.J. Rutherford and H. Hamilton. 210 pp.

DESCRIPTION: Current drilling waste disposal practices are reviewed and criteria in Alberta guidelines are assessed. The report also identifies research needs and indicates mitigation measures. A manual provides a decision-making flowchart to assist in selecting methods of environmentally safe waste disposal.

- ** 28. RRTAC 87-2: Minesoil and Landscape Reclamation of the Coal Mines in Alberta's Mountains and Foothills. A.W. Fedkenheuer, L.J. Knapik and D.G. Walker. 174 pp.

DESCRIPTION: This report reviews current reclamation practices with regard to site and soil reconstruction and re-establishment of biological productivity. It also identifies research needs in the Mountain-Foothills area. The study was co-funded with The Coal Association of Canada.

- ** 29. RRTAC 87-3: Gel and Saline Drilling Wastes in Alberta: Workshop Proceedings. D.A. Lloyd (compiler). 218 pp.

DESCRIPTION: Technical papers were presented which describe: mud systems used and their purpose; industrial constraints; government regulations, procedures and concerns; environmental considerations in waste disposal; and toxic constituents of drilling wastes. Answers to a questionnaire distributed to participants are included in an appendix.

- * 30. RRTAC 87-4: Reclamation Research Annual Report - 1986. 50 pp.

DESCRIPTION: This report details the Reclamation Research Program indicating priorities, descriptions of each research project, researchers, results, and expenditures.

- * 31. RRTAC 87-5: Review of the Scientific Basis of Water Quality Criteria for the East Slope Foothills of Alberta. Beak Associates Consulting Ltd. 46 pp.

DESCRIPTION: The report reviews existing Alberta guidelines to assess the quality of water drained from coal mine sites in the East Slope Foothills of Alberta. World literature was reviewed within the context of the East Slopes environment and current mining operations. The ability of coal mine operators to meet the various guidelines is discussed. The study was co-funded with The Coal Association of Canada.

- ** 32. RRTAC 87-6: Assessing Design Flows and Sediment Discharge on the Eastern Slopes. Hydrocon Engineering (Continental) Ltd. and Monenco Consultants Ltd. 97 pp.

DESCRIPTION: The report provides an evaluation of current methodologies used to determine sediment yields due to rainfall events in well-defined areas. Models are available in Alberta to evaluate water and sediment discharge in a post-mining situation. SEDIMOT II (Sedimentology Disturbed Modelling Techniques) is a single storm model that was developed specifically for the design of sediment control structures in watersheds disturbed by surface mining and is well suited to Alberta conditions. The study was co-funded with The Coal Association of Canada.

- * 33. RRTAC 87-7: The Use of Bottom Ash as an Amendment to Sodic Spoil. S. Fullerton. 83 pp.

DESCRIPTION: The report details the use of bottom ash as an amendment to sodic coal mine spoil. Several rates and methods of application of bottom ash to sodic spoil were tested to determine which was the best at reducing the effects of excess sodium and promoting crop growth. Field trials were set up near the Vesta mine in East Central Alberta using ash readily available from a nearby coal-fired thermal generating station. The research indicated that bottom ash incorporated to a depth of 30 cm using a subsoiler provided the best results.

- * 34. RRTAC 87-8: Waste Dump Design for Erosion Control. R.G. Chapiuk and S.E. Thornton. 45 pp.

DESCRIPTION: This report describes a study to evaluate the potential influence of erosion from reclaimed waste dumps on downslope environments such as streams and rivers. Sites were selected from coal mines in Alberta's mountains and foothills, and included resloped dumps of different configurations and ages, and having different vegetation covers. The study concluded that the average annual amount of surface erosion is minimal. As expected, erosion was greatest on slopes which were newly regraded. Slopes with dense grass cover showed no signs of erosion. Generally, the amount of erosion decreased with time, as a result of initial loss of fine particles, the formation of a weathered surface, and increased vegetative cover.

- ** 35. RRTAC 87-9: Hydrogeology and Groundwater Chemistry of the Battle River Mining Areas. M.R. Trudell, R.L. Faught and S.R. Moran. 97 pp.

DESCRIPTION: This report describes the premining geologic conditions in the Battle River coal mining area including the geology as well as the groundwater flow patterns, and the groundwater quality of a sequence of several water-bearing formations extending from the surface to a depth of about 100 metres.

- ** 36. RRTAC 87-10: Soil Survey of the Plains Hydrology and Reclamation Project - Battle River Project Area. T.M. Macyk and A.H. MacLean. 62 pp. plus 8 maps.

DESCRIPTION: The report evaluates the capability of post-mining landscapes and assesses the changes in capability as a result of mining, in the Battle River mining area. Detailed soils information is provided in the report for lands adjacent to areas already mined as well as for lands that are destined to be mined. Characterization of the reconstructed soils in the reclaimed areas is also provided. Data were collected from 1979 to 1985. Eight maps supplement the report.

- ** 37. RRTAC 87-11: Geology of the Highvale Study Site: Plains Hydrology and Reclamation Project. A. Maslowski-Schutze. 78 pp.

DESCRIPTION: The report is one of a series that describes the geology, soils and groundwater conditions at the Highvale Coal Mine study site. The purpose of the study was to establish a summary of site geology to a level of detail necessary to provide a framework for studies of hydrogeology and reclamation.

- ** 38. RRTAC 87-12: Premining Groundwater Conditions at the Highvale Site. M.R. Trudell and R. Faught. 83 pp.

DESCRIPTION: This report presents a detailed discussion of the premining flow patterns, hydraulic properties, and isotopic and hydrochemical characteristics of five layers within the Paskapoo Geological Formation, the underlying sandstone beds of the Upper Horseshoe Canyon Formation, and the surficial glacial drift.

- * 39. RRTAC 87-13: An Agricultural Capability Rating System for Reconstructed Soils. T.M. Macyk. 27 pp.

DESCRIPTION: This report provides the rationale and a system for assessing the agricultural capability of reconstructed soils. Data on the properties of the soils used in this report are provided in RRTAC 86-2.

- ** 40. RRTAC 88-1: A Proposed Evaluation System for Wildlife Habitat Reclamation in the Mountains and Foothills Biomes of Alberta: Proposed Methodology and Assessment Handbook. T.R. Eccles, R.E. Salter and J.E. Green. 101 pp. plus appendix.

DESCRIPTION: The report focuses on the development of guidelines and procedures for the assessment of reclaimed wildlife habitat in the Mountains and Foothills regions of Alberta. The technical section provides background documentation including a discussion of reclamation planning, a listing of reclamation habitats and associated key wildlife species, conditions required for development, recommended revegetation species, suitable reclamation techniques, a description of the recommended assessment techniques and a glossary of basic terminology. The assessment handbook section contains basic information necessary for evaluating wildlife habitat reclamation, including assessment scoresheets for 15 different reclamation habitats, standard methodologies for measuring habitat variables used as assessment criteria, and minimum requirements for certification. This handbook is intended as a field manual that could potentially be

used by site operators and reclamation officers. The study was co-funded with The Coal Association of Canada.

- ** 41. RRTAC 88-2: Plains Hydrology and Reclamation Project: Spoil Groundwater Chemistry and its Impacts on Surface Water. M.R. Trudell (compiler). 135 pp.

DESCRIPTION: Two reports comprise this volume. The first "Chemistry of Groundwater in Mine Spoil, Central Alberta," describes the chemical make-up of spoil groundwater at four mines in the Plains of Alberta. It explains the nature and magnitude of changes in groundwater chemistry following mining and reclamation. The second report, "Impacts of Surface Mining on Chemical Quality of Streams in the Battle River Mining Area," describes the chemical quality of water in streams in the Battle River mining area, and the potential impact of groundwater discharge from surface mines on these streams.

- ** 42. RRTAC 88-3: Revegetation of Oil Sands Tailings: Growth Improvement of Silver-berry and Buffalo-berry by Inoculation with Mycorrhizal Fungi and N₂-Fixing Bacteria. S. Visser and R.M. Danielson. 98 pp.

DESCRIPTION: The report provides results of a study: (1) To determine the mycorrhizal affinities of various actinorrhizal shrubs in the Fort McMurray, Alberta region; (2) To establish a basis for justifying symbiont inoculation of buffalo-berry and silver-berry; (3) To develop a growing regime for the greenhouse production of mycorrhizal, nodulated silver-berry and buffalo-berry; and, (4) To conduct a field trial on reconstructed soil on the Syncrude Canada Limited oil sands site to critically evaluate the growth performance of inoculated silver-berry and buffalo-berry as compared with their uninoculated counterparts.

- ** 43. RRTAC 88-4: Plains Hydrology and Reclamation Project: Investigation of the Settlement Behaviour of Mine Backfill. D.R. Pauls (compiler). 135 pp.

DESCRIPTION: This three part volume covers the laboratory assessment of the potential for subsidence in reclaimed landscapes. The first report in this volume, "Simulation of Mine Spoil Subsidence by Consolidation Tests," covers laboratory simulations of the subsidence process particularly as it is influenced by resaturation of mine spoil. The second report, "Water Sensitivity of Smectitic Overburden: Plains Region of Alberta," describes a series of laboratory tests to determine the behaviour of overburden materials when brought into contact with water. The report entitled "Classification System for Transitional Materials: Plains Region of Alberta," describes a lithological classification system developed to address the characteristics of the smectite rich, clayey transition materials that make up the overburden in the Plains of Alberta.

- ** 44. RRTAC 88-5: Ectomycorrhizae of Jack Pine and Green Alder: Assessment of the Need for Inoculation, Development of Inoculation Techniques and Outplanting Trials on Oil Sand Tailings. R.H. Danielson and S. Visser. 177 pp.

DESCRIPTION: The overall objective of this research was to characterize the mycorrhizal status of Jack Pine and Green Alder which are prime candidates as reclamation species for oil sand tailings and to determine the potential benefits of mycorrhizae on plant performance. This entailed determining the symbiont status of container-grown nursery stock and the quantity and quality of inoculum in reconstructed soils, developing inoculation techniques and finally, performance testing in an actual reclamation setting.

- * 45. RRTAC 88-6: Reclamation Research Annual Report - 1987. Reclamation Research Technical Advisory Committee. 67 pp.

DESCRIPTION: This annual report describes the expenditure of \$500,000.00 of Alberta Heritage Savings Trust Fund monies on research under the Land Reclamation Program. The report outlines the objectives and research strategies of the four program areas, and describes the projects funded under each program.

- * 46. RRTAC 88-7: Baseline Growth Performance Levels and Assessment Procedure for Commercial Tree Species in Alberta's Mountains and Foothills. W.R. Dempster and Associates Ltd. 66 pp.

DESCRIPTION: Data on juvenile height development of lodgepole pine and white spruce from cut-over or burned sites in the Eastern Slopes of Alberta were used to define reasonable expectations of early growth performance as a basis for evaluating the success of reforestation following coal mining. Equations were developed predicting total seedling height and current annual height increment as a function of age and elevation. Procedures are described for applying the equations, with further adjustments for drainage class and aspect, to develop local growth performance against these expectations. The study was co-funded with The Coal Association of Canada.

Available from: Publication Services
Queen's Printer
11510 Kingsway Avenue
Edmonton, Alberta T5G 2Y5

- * A \$5.00 fee is charged for handling and postage.
- ** A \$10.00 fee is charged for handling and postage.
- *** A \$20.00 fee is charged for handling and postage.
- N/A Not available for purchase but available for review at the Alberta Environment Library, 14th Floor, 9820 - 106 Street, Edmonton, Alberta T5K 2J6

GENERAL INTRODUCTION

A major focus of the joint Reclamation Research Technical Advisory Committee - Coal Association of Canada Mountains and Foothills Reclamation Research Program was the control of surface runoff and sedimentation on coal mines in the east slopes. Monenco Consultants Limited (1986) noted that "there has been increasing concern in recent years regarding the environmental impact of sediment laden runoffs discharged from land disturbing activities in Alberta".

Models are often used to predict runoff and potential sediment load, and from these predictions to develop plans for sediment control structures. These sedimentology models generally make use of outputs from some form of watershed hydrology model (Monenco Consultants Limited 1986). Predictions from the sedimentology models are extremely sensitive to variability in hydrology model outputs. This illustrates the need for quality input data relevant to the site under consideration.

Hydrocon Engineering (Continental) Ltd. and Monenco Consultants Limited (1987) evaluated currently available rainfall runoff sediment production methodologies. They found a need for quality controlled data on: rainfall intensity, duration and timing; streamflow discharge; sediment concentrations; and, eroded particle size distributions.

The collection of hydrometric, water quality and hydrometeorologic information is a complex task. A variety of instruments and measurement methods are required to produce a record of hydrologic inputs and outputs for a watershed basin.

There is a growing awareness and recognition that standardization of data acquisition methods is required to ensure data comparability, and to allow comparison of data analyses.

To ensure acceptable quality of data, agreement must be reached among the operating, contributing and user agencies on methods to be used in measuring and sampling data. The purpose of this manual is to assist those involved in the field of data acquisition by outlining methods, practices and instruments which are reliable and recognized by the International Organization for Standardization.

REFERENCES:

Hydrocon Engineering (Continental) Ltd. and Monenco Consultants Ltd. 1987. Assessing Design Flows and Sediment Discharge on the Eastern Slopes. The Coal Association of Canada and Alberta Land Conservation and Reclamation Council Report #RRTAC 87-6. 97 pp.

Monenco Consultants Ltd. 1986. Critical Analysis of Settling Pond Design and Alternative Technologies. The Coal Association of Canada and Alberta Land Conservation and Reclamation Council Report #RRTAC 86-1. 372 pp.

TABLE OF CONTENTS

General Introduction

Section 1 Measurement of Precipitation

Section 2 Measurement of Streamflow

Section 3 Water Quality - Field Sampling Procedures

Section 4 Water Quality - Analytical Chemistry Procedures

**ALBERTA FOREST SERVICE WATERSHED MANAGEMENT
FIELD AND LABORATORY METHODS**

**PART 1
MEASUREMENT OF
PRECIPITATION**

by

A.M.-K. Nip and R.A. Hursey



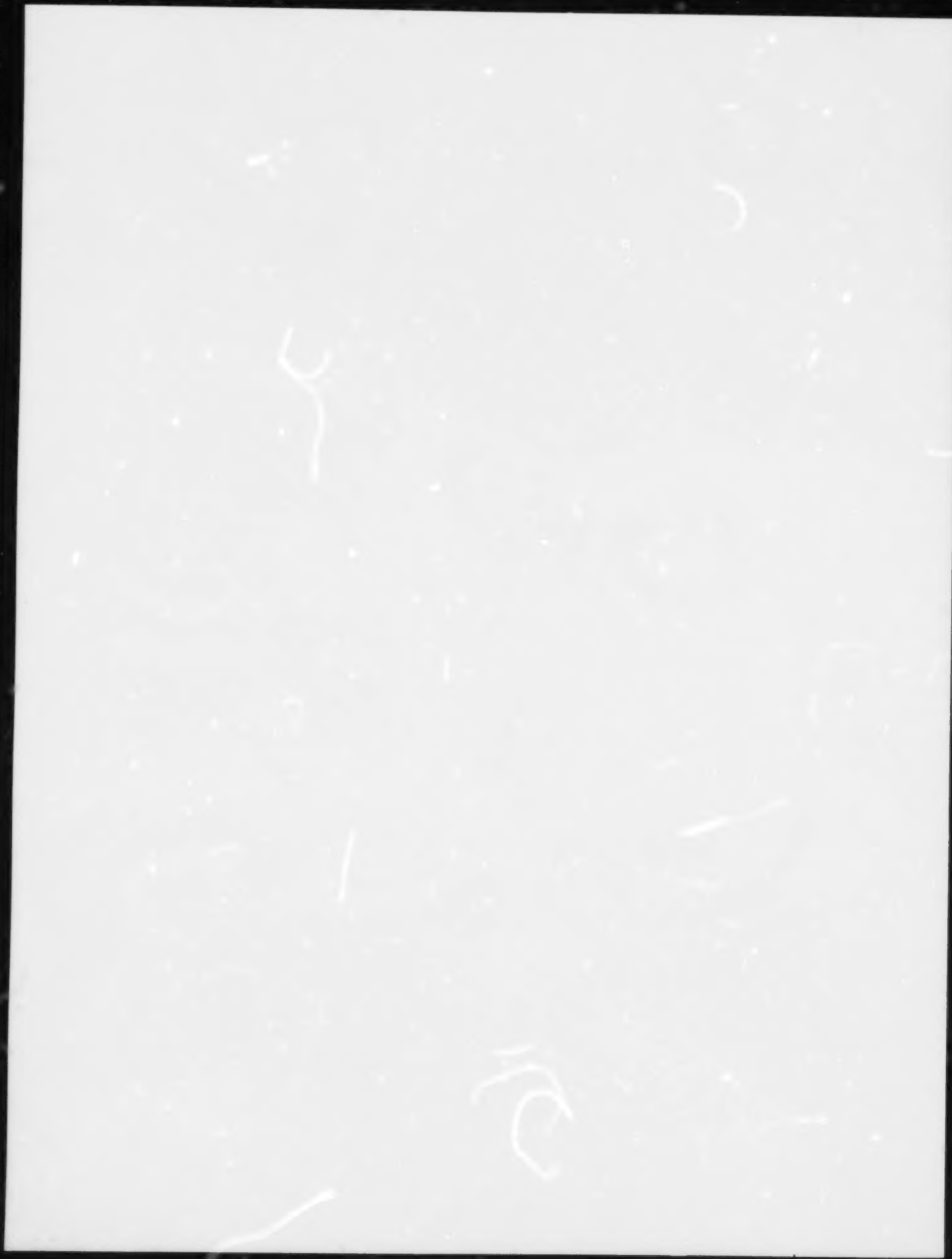
TABLE OF CONTENTS

	Page
1. GENERAL INTRODUCTION	1
2. NON-RECORDING PRECIPITATION GAUGES	3
2.1 Standard Rain Gauge	3
2.2 Sacramento Precipitation Gauge	7
Installation	7
Measurement and Maintenance	11
3. MEASUREMENT OF SNOW	16
3.1 Introduction	16
3.2 Safety Considerations	16
3.3 Quality Control	16
3.4 Snow Course Selection and Network Design.	17
3.5 Equipment List	19
3.6 Preparation for Field Work	20
3.7 Field Procedure	22
General Notes	22
Sampling Procedure	23

	Page
3.8 Analysis and Reporting	25
Calculations	26
Reporting	26
3.9 Cleanup and Storage	27
4. RECORDING GAUGES	28
4.1 Fisher-Porter Recording Gauge	28
4.2 Tipping Bucket Rain Gauge	30
Installation	30
4.3 Belfort Precipitation Gauge	35
Stand Construction	35
Pre-Installation Assembly	36
Installation	36
Operation	43
Gauge Winterization	48
Maintenance	50
5. PRECIPITATION INFORMATION AGENCIES	52
GENERAL REFERENCES	53

LIST OF ILLUSTRATIONS

Figure	Page
1. Type B Rain Gauge.....	4
2. Copper Rain Gauge.....	6
3. Sacramento Rain Gauge.....	8
4. Form FLU 503/84.....	12
5. Sacramento Conversion Table	15
6. Mount Rose Sampler.....	20
7. Snow Survey Form.....	21
8. Fisher-Porter Recording Gauge Chart.....	29
9. Tipping Bucket Rain Gauge.....	31
10. Universal Recording Rain Gauge.....	37
11. Rain Gauge Mechanism, Single Spring.....	38
12. Removal of Dashpot.....	41
13. Rain Gauge Mechanism, Rear View.....	44



GENERAL INTRODUCTION

The collection of hydrometric, water quality and hydrometeorologic information is a complex task. A variety of instruments and measurement methods are required to produce a record of hydrologic inputs and outputs for a watershed basin.

There is a growing awareness and recognition that standardization of data acquisition methods is required to ensure data comparability, and to allow comparison of data analyses.

To ensure acceptable quality of data, agreement must be reached among the operating, contributing and user agencies on methods to be used in measuring and sampling data. The purpose of this manual is to assist those involved in the field of data acquisition by outlining methods, practices and instruments which are reliable and recognized by the International Organization for Standardization.

1. INTRODUCTION

Precipitation is considered the most important component of the hydrologic cycle for watershed management purposes. It occurs as both a liquid and a solid, so various types of sampling gauges have been developed to fit the different conditions under which precipitation must be sampled.

One class of precipitation samplers is non-recording such as the standard rain gauge and the Sacramento precipitation gauge.

There are also recording gauges such as the Fisher - Porter precipitation gauge, the Belfort precipitation gauge and the tipping bucket recording rain gauge.

For snow measurement snow courses are used, which are a series of locations where the snow water content is measured throughout the winter and later correlated to the runoff from the watershed. A Mount Rose Sampler is used to determine the water content of the snow on the ground.

Each of these types of precipitation measurement devices and methods is discussed in this volume.

2. NON-RECORDING PRECIPITATION GAUGES

2.1 Standard Rain Gauge

As the name indicates, this type of gauge is the standard for measurement of precipitation as rainfall during the frost-free period of the year. This period is usually considered to be between May 1st and the October 31st in Alberta.

There are two types of the standard rain gauge currently being used. The first is a copper Ministry of Transport (MOT) gauge with a separate glass measuring vial calibrated to 0.01 inch of precipitation. The second is a "Type B" plastic gauge (Figure 1.1) which is calibrated in metric units. At this time the copper MOT gauges are being phased out.

Either of these gauges should be located on a flat area of open cut grass.

The gauges should be located in a clearing at a height at least two times but not more than five times the height of the surrounding objects.

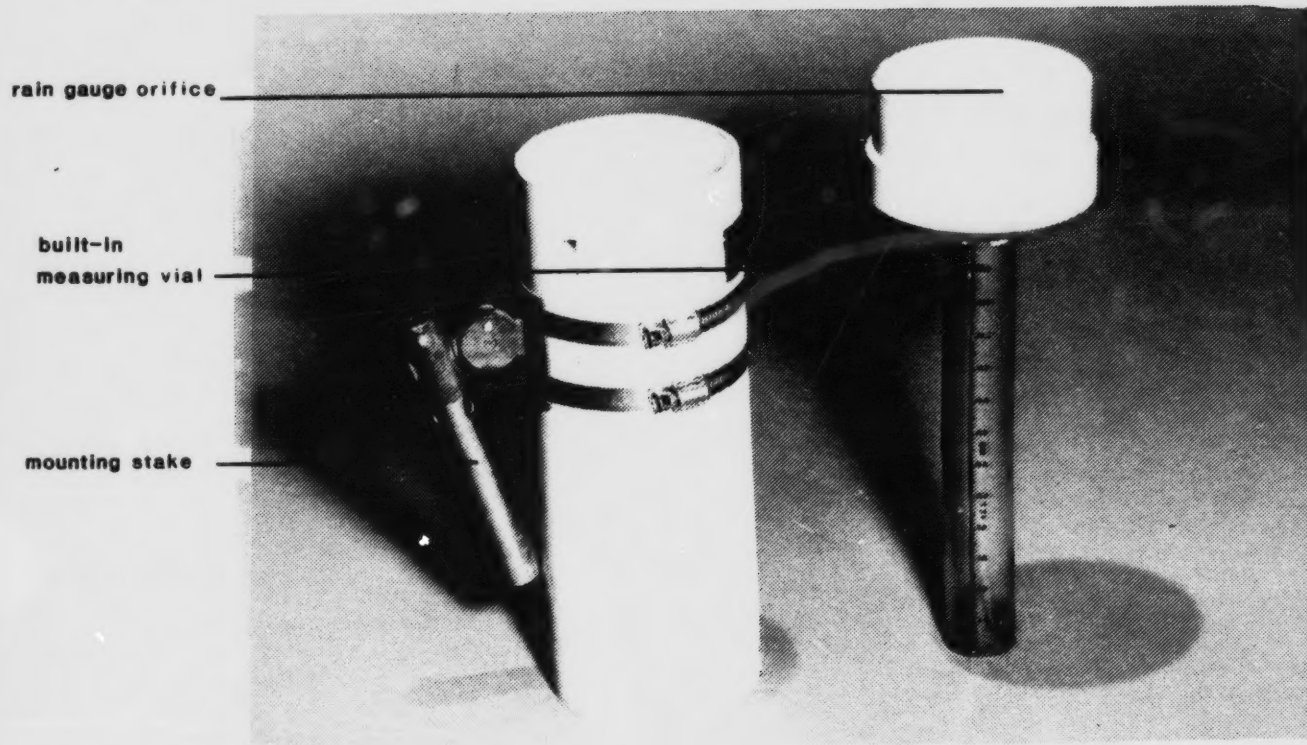


Fig. 1. TYPE B RAIN GAUGE

The top opening of the gauge must be circular and level.

The copper MOT gauge is usually nailed to a tree stump or on the top of a wooden stake driven in the ground to form a firm and level platform.

The plastic gauge is mounted on a stake made of pipe with the rim of the gauge high enough to clear one month's grass growth (See Figure 2).

The water level in the plastic gauge is read at the lowest point of the meniscus to the closest 0.2 mm.

It is advisable to remove the plastic measuring vial from the gauge during periods of frost to prevent breakage due to expansion of melting ice. The gauges should be brought inside for storage during the winter months.

The standard rain gauge is designed to be read either daily or weekly. However, when heavy precipitation periods occur the gauge must be read often enough so that it does not overflow with resultant loss of data.

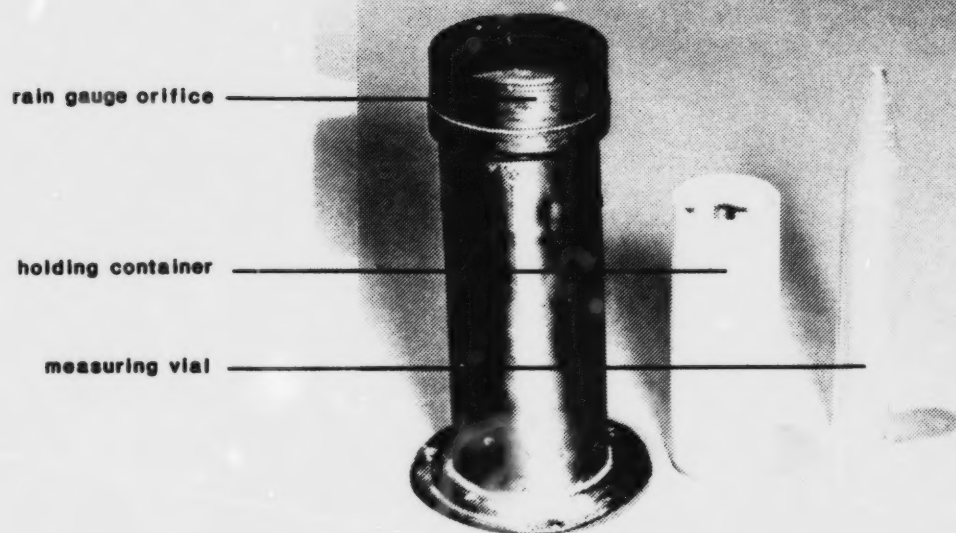


Fig. 2. COPPER RAIN GAUGE,

2.2 Sacramento Precipitation Gauge

The Sacramento precipitation gauge (Figure 3) is an inexpensive precipitation collecting device suitable for use in remote locations throughout the entire year.

These gauges are measured at least twice each year, on May 1st and October 1st. Some gauges near ranger stations are measured at the end of each month. In addition, the Forest Weather Section requires measurement of some gauges to be taken on November 1st and April 1st to help determine fire indices.

Whatever the schedule, it is vital to take the measurements at the appointed times to ensure that precipitation values are comparable over all regions of the province.

Installation Refer to Figure 3 for illustration of the installation procedure.

The tools required for setting up the gauge are a crescent wrench, a spade, pliers, two plastic pails with water, a socket set, a carpenter's level, a pipe wrench, vise grips, a sledge hammer and a metre stick.

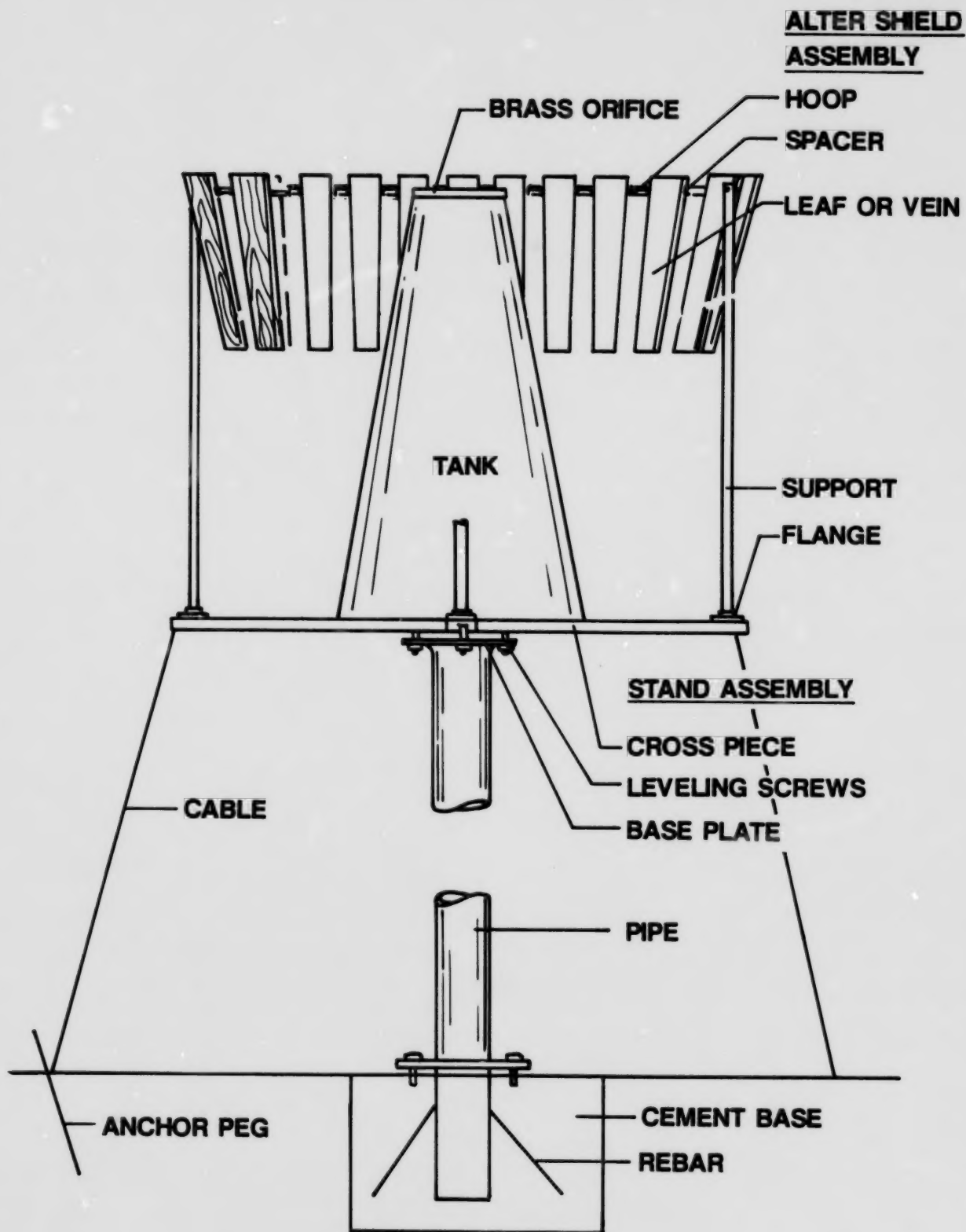


Fig. 3. SACRAMENTO PRECIPITATION STORAGE GAUGE.

1. The preferred size of a clearing for a Sacramento precipitation gauge is at least two but not more than five tree heights in diameter.

2. Dig a hole where the gauge is to be placed that is large enough to hold three bags of ready-mix CEMENT, but not deeper than the BASE PLATE. Do not pour the CEMENT until the gauge is completely assembled in place.

3. Attach the STAND to the BASE PLATE with bolts. Slip the LADDER into the CROSS PIECE brackets and loosely bolt the CROSS PIECE to the top of the STAND.

4. Pound four ANCHOR PEGS into the ground to serve as the corners of the assembly. Drive the ANCHOR PEGS into the ground at an angle as shown in Figure 3 to ensure that they will resist lifting stresses. Attach CABLES to the ANCHOR PEGS and to the CROSS PIECE at the chain links provided. Tighten the CABLES and level the STAND so that it is vertical.

5. Bolt the ALTER SHIELD to the CROSS PIECE. Release the ALTER SHIELD vanes so that they will move freely in the wind.

6. Bolt the TANK onto the CROSS PIECE. Make sure that all bolts and CABLES are tightened. Place a carpenter's level across the top of the TANK and carefully level the CROSS PIECE by means of the LEVELLING BOLTS.

7. Wet the CEMENT, mix it properly and pour it into the hole around the BASE. Do not cover the BASE PLATE. If the gauge has to be moved it can easily be unbolted from the BASE as long as the BASE PLATE is not embedded in concrete.

8. Pour antifreeze and light oil into the tank and measure the volume in millimetres. This is the zero reading for the year. Refer to the Measurement and Maintenance section which follows to determine the correct amount of antifreeze and light oil required.

9. Record the ground-level elevation of the gauge, the legal land description, latitude and longitude, date installed and the initial reading (from step 8).

10. Each time the gauge is measured be sure to check the CABLES and bolts for tightness, and check that the gauge is still levelled properly.

Measurement and Maintenance.

1. When the gauge is initially installed antifreeze and light oil are placed in it as mentioned above. For cylindrical gauges four litres of antifreeze are required, while eight litres are required for conical gauges. A half litre of light oil, such as Voltesso, is then poured on top of the antifreeze to prevent evaporation.

Form 503/84 (Figure 4) is used to record the gauge number, date, the depth of liquid in the gauge measured with a metre stick, and comments.

The depth of liquid in the gauge is read by inserting a metre stick into the centre of the gauge and reading the wetted portion of the metre stick to the nearest millimetre.

NOTE Always double check the measurements.

This first measurement of the antifreeze and oil in the gauge is commonly referred to as the "recharge" or "zero" reading. Record this first reading in the COMMENTS column as the "recharged Sacramento".

ENERGY AND NATURAL RESOURCES
Alberta Forest Service

[illegible]

The comment column above should contain notes on information considered pertinent to the record such as: An estimate of what proportion of the month's precipitation fell as snow, the date and intensity of major storms (standard rain gauge reading), the date and initial reading after gauge was recharged, the date and manner in which the gauge may have been damaged, the depth of snow on the ground adjoining the gauge, condition of gauge, etc.

Fig. 4. FORM FLU 503/84

At times during the winter the contents of the gauge may stiffen or solidify from the cold temperatures. Stir the contents to mix the water from precipitation and the antifreeze. This should alleviate the problem.

2. Gauges located at Ranger Stations should be measured on the first of each month throughout the year. The results of these measurements are submitted on form FLU 503/84 (Figure 4) each month to both the Forest Headquarters and to the Watershed Management Section in Edmonton.

3. All gauges are measured on May 1st to determine the amount of precipitation collected over the winter.

NOTE Do not dump or discard the contents of the precipitation gauge.

The report of these measurements is submitted on form FLU 503/84 to the Watershed Management Section in Edmonton.

4. A measurement of all gauges is taken again on October 1st to determine the amount of precipitation collected over the summer. These measurements are also sent to the Watershed Management Section in Edmonton for distribution to interested users.

5. After the October 1st measurement the contents of the gauges are dumped. The precipitation gauges are then refilled with antifreeze and oil as directed in step one of this procedure. Measure the depth in the gauge after recharging and record this as a "recharged Sacramento". When the gauges are serviced in October they should be checked to be sure that they are level and in good condition. Tighten the CABLES and bolts as required.

6. Converted readings, which must be calculated for the conical gauges, because the depth of liquid in a cone does not directly reflect the amount of precipitation collected can be calculated using the following formula:

$$Y = 0.346 + 6.512X - 0.004X^2$$

Where:

X = the depth of fluid in the gauge (ruler reading)

Y = the converted amount of precipitation.

or by using the Sacramento Conversion Table on the following page.

Actual Precipitation = Present converted amount of
precipitation - Previous
converted amount of precipitation

$$Y = 0.346 + 0.512x - 0.006x^2$$
[illegible]

Fig. 5. SACRAMENTO CONVERSION TABLE.

3. Measurement of Snow

3.1 Introduction

Snow is measured using the Mount Rose Sampler. This sampler is specifically designed to allow determination of the depth of the snow cover, the density of the snow and how much water (read as inches of precipitation) is contained in the snow. This information allows prediction of the amount of runoff water that can be expected when the snow melts in the spring.

3.2 Safety Considerations

In general, the only safety precaution which must be observed when taking snow samples are those which are appropriate for outdoor work under the prevailing weather conditions. The common sense procedure of obtaining a current weather report before departing for the field should be observed because snow sampling requires that the work be conducted away from the vehicle.

1.3.3 Quality Control

Quality control when sampling snow requires a good deal of common sense as well as careful adherence to the field procedures outlined in this chapter. Sampling from sites that

are not representative of the general snow cover is generally a waste of time and effort except for special studies. Therefore, the field scientist needs to be familiar with the characteristics of snow fall and redistribution, and willing to exert the extra effort to reach and sample representative areas of the snowpack.

The Mount Rose Sampler is designed to obtain a plug consisting of litter and even frozen soil at the end of the snow core. Care must be taken to remove this material from the sampling tube before weights are taken to ensure that there is an accurate weight of water obtained. Also, this plug of litter and soil must be removed to obtain the actual length of the snow core and depth of snow on the ground.

Sampling locations should be located so that there are no sources of pollution from routine air or ground traffic, and no storage of fuels or other foreign materials within 100 m of the place where the samples are taken.

1.3.4 Snow Course Selection and Network Design

The conventional snow course is a selected line of marked sampling points where snow depth, density and water equivalency are measured.

The length of the snow course and the distance between sampling points will vary depending on site conditions, the uniformity of snow cover and the study objectives.

The most common design is a 10-point snow course, where the distance between the sampling points is 30 m.

The location of a snow course will depend on the purpose the snow course serves. Gray and Male (1981) have listed a few general guidelines for establishing a snow course.

1. The sites should be selected so it will yield consistent results over time. The permanence of the site and the continuity of record are key factors in site selection.
2. The site should be accessible by foot, skis or a vehicle.
3. Individual sampling points should be located away from surface irregularities such as logs, boulders and shrubs.
4. After a site has been selected it should be clearly marked, mapped and documented so that it can be found after heavy snowfall.

3.5 Equipment List

The Mount Rose Sampler comes as a complete unit containing a weigh scale, sections of snow tubes, an adjustable snow tube handle and a plug remover (Figure 6).

Other than the normal field equipment and the proper field data recording forms no other equipment is required.

3.6 Preparation for Field Work

Before going to the field to take snow samples the Mount Rose Sampler should be checked to make sure that all the pieces are together and in working condition. The weigh scale should be checked with a series of known weights to be sure it is registering the correct weight. The sections of tube should be examined to be sure that they are not dented, bent or otherwise unserviceable.

An adequate supply of SNOW SURVEY FORMS (Figure 7) must be taken to the field.

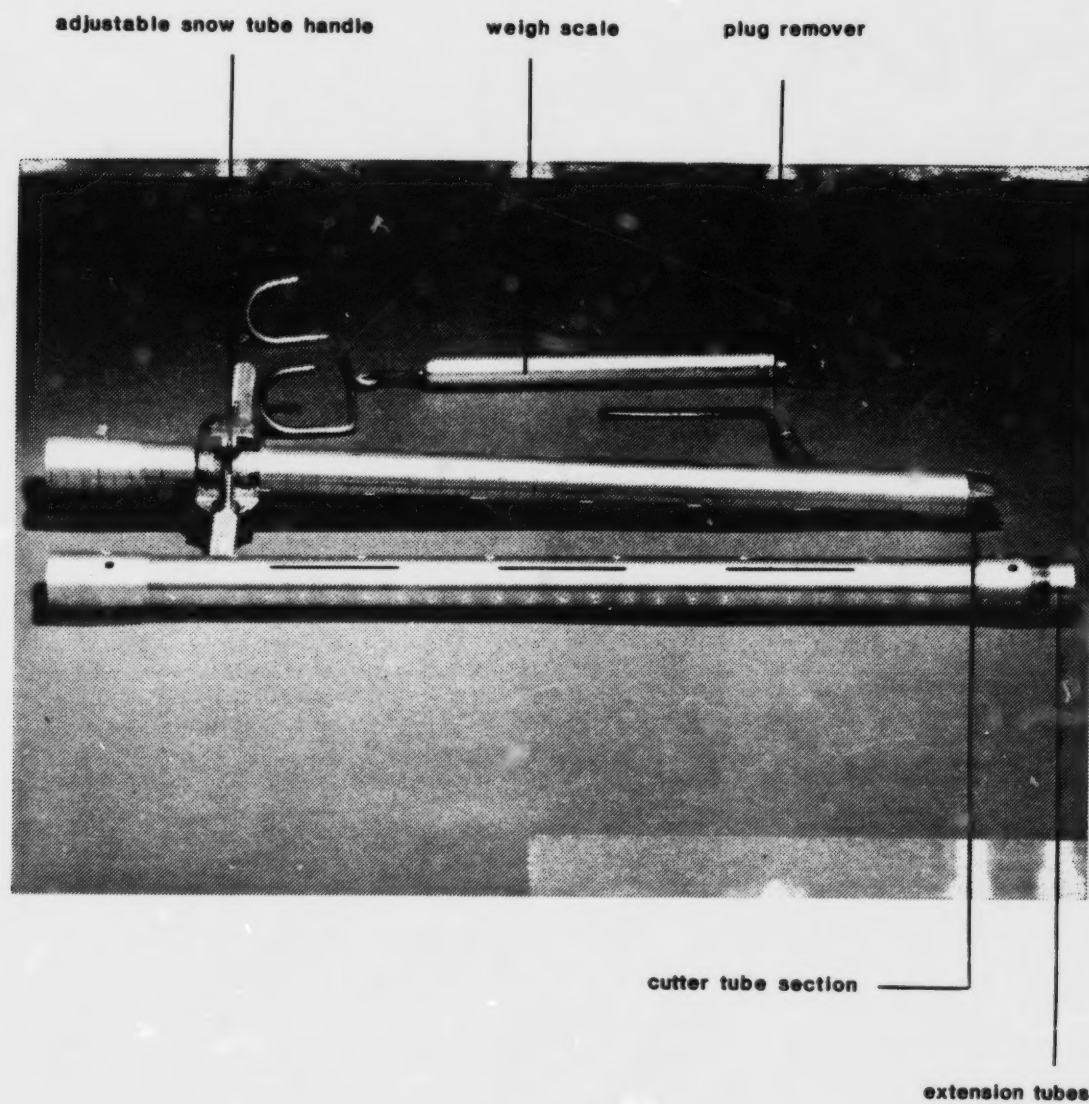


Fig. 6. MOUNT ROSE SNOW SAMPLER.

SNOW SURVEY FORM

Station _____ Date _____

Location _____ Elevation _____

Sample Number	Depth of Snow Inches	Length of Core Inches	Weight of Tube & Core	Weight of Empty Tube	Water Content Inches	Density Per Cent	Remarks
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
MEAN							

Time Survey Started _____ Time Ended _____

Crust _____

Soil Condition _____

Weather _____

Observers _____

Fig. 7, SNOW SURVEY FORM.

3.7 Field Procedure

General Notes.

The conditions of the site and the immediate area (within a minimum of 100 m) are important to the evaluation of the sample.

If the site is part of a snow course which is sampled repeatedly it is particularly important to note any evidence of disturbance of the site by humans or other animals, or by mass movement of either the snow or the underlying substrate.

If the site is not part of a regular snow course, with a complete site description already on file, the description of the site must include such as slope, aspect, exposure, vegetation and density of cover, and elevation in addition to the information normally recorded for a snow course location.

Remember to ensure that the site is not within 100 m of any source of air pollution or other probable disturbance.

As always, notes must be kept of any difficulties encountered collecting the samples. This information can be critically important in interpreting the data in instances when the data contain some unexpected element such as an unusual per cent density for the snow.

Sampling Procedure

1. On the SNOW SURVEY FORM, record the Station, Location, Date, Elevation, Time Survey Started, whether there is a Crust, Soil Condition (whether the soil is frozen or not), Weather conditions and the names of the Observers.
2. Decide on the number of sections of the snow tubes required to sample the range of snow depths at the location and screw them together. Place the adjustable snow tube handle in the slotted openings of the snow tubes.
3. Weigh the prepared snow tubes on the weigh scale. Be sure to read the black scale on the weigh scale. Record the weight on the SNOW SURVEY FORM in the column marked Weight of Empty Tube. (The red scale is in centimetres.)
4. Place the snow tubes perpendicular to the ground surface and screw them into the snow until they reach the ground surface. Record the depth of snow from the scale on the snow tubes.

NOTE: Ensure the cutting edge of the snow tube penetrates beyond the bottom of the snow. This can be checked after the snow tube is withdrawn to determine whether the snow core is sealed with a plug (litter or soil).

5. Withdraw the snow tubes from the snow, being careful not to dislodge any part of the sample from the snow tubes.

6. Measure the length of the snow core and record this in the column Length of Core. This can be expected to differ from the measured depth of the snow. An indication of whether the sample taken was representative is to determine the ratio of the length of the core to the depth of snow. If this ratio ranges between .6 and 1, then the sample is to be representative. If the ratio falls below 0.6, a new sample must be taken.

7. Remove any debris such as moss, litter or frozen soil from the end of the snow tube with care by inserting the plug remover into the bottom slot of the snow tube and then push the debris out through the cutting edge of the snow tube. Measure the length of the snow tube which was taken up by the debris and record this amount on the SNOW SURVEY form in the column marked Plug.

8. Weigh the snow tubes complete with snow core, but with the plug removed. Record this weight on the SNOW SURVEY FORM in the column Weight of Tube and Core.

9. Turn the snow tube upside down and remove the snow core with a plunger or stick. DO NOT STRIKE THE TUBE WITH ANYTHING OR STRIKE THE TUBE AGAINST ANYTHING. Snow tubes are easily damaged and the replacement cost is over \$2 000.

10. Repeat steps 3 through 9 for each sample at each location. When all the samples at one location have been taken move on to the next location and start again at step 1. of the Sampling Procedure.

NOTE Repack the Mount Rose Sampler before relocating to prevent damage. Considerable time can be wasted returning to headquarters to replace a bent snow tube.

3.8 Analysis and Reporting

No scientific work is completed until the data collected have been analysed and properly reported. This should be done as soon as the crew returns from the field to headquarters and the equipment has been properly unloaded and is drying.

Calculations

Refer to Figure 6, SNOW SURVEY FORM. To obtain the actual Depth of Snow, the length of the Plug is subtracted from the measured Snow Depth. To obtain the actual length of the core, the length of the Plug is subtracted from the measured Length of Core.

To obtain the Water Content, subtract the Weight of Empty Tube from the Weight of Tube & Core for each sample.

To obtain the Density Per Cent, divide the Water Content by the actual Depth of Snow.

Reporting

The complete report should be forwarded to interested parties once the data on the SNOW SURVEY FORM have been calculated and the field descriptive notes have been compiled.

3.9 Cleanup and Storage

As soon as the equipment is brought back from the field it must be carefully dried and cleaned to prevent corrosion during storage.

Check all the equipment for wear or damage. The threads on the ends of the sample tubes are a point of special concern, as is the possibility that one of the tubes has been bent or dented. The operation of the weigh scale should also be checked against known weights. If it no longer weighs correctly a note must be made in the report and the weigh scale sent for recalibration.

Carefully pack and store all equipment and supplies in clean dry conditions. It is good practice to go through the equipment list (section 3.4) as the equipment is placed in storage to make sure that nothing will be missing or broken the next time it is necessary to prepare for field work.

4. Recording Gauges

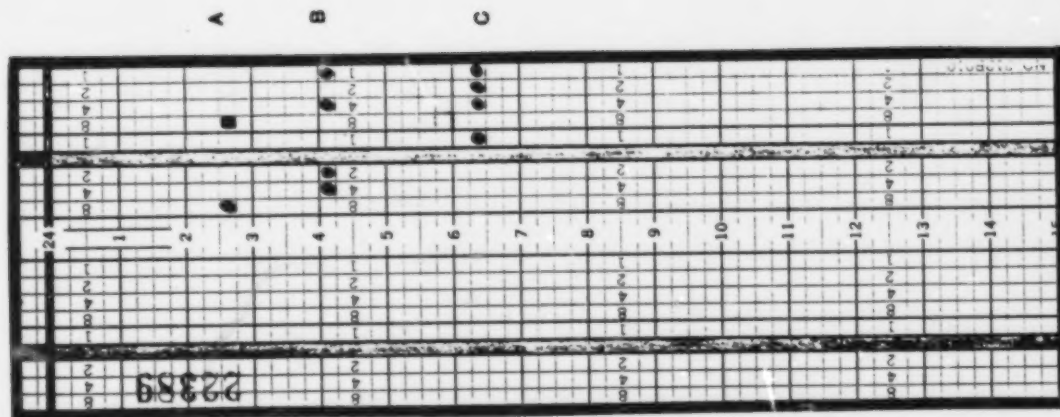
4.1 Fisher-Porter Recording Gauge

These recording gauges are installed and maintained by Atmospheric Environment Services of Environment Canada, and by Alberta Environment. Those gauges which are not transmitting data by telemetry must be checked weekly or as often as possible.

Mark the following information on the chart (Figure 8) when checking the gauge: date, time, and chart record.

Wait for the chart drive to punch the tape (once every 15 minutes) before drawing a line across the chart to indicate that the instrument has been checked.

To record the amount of precipitation collected the values must be summed across the chart. The black line (Figure 8) is the decimal point marker.



Example:

A) 8.8

B) $(4 + 2) \cdot (4 + 1) = 8.5$

C) $1 \cdot (4 + 2 + 1) = 1.7$

Fig. 8. FISHER-PORTER RECORDING CHART .

4.2 Tipping Bucket Rain Gauge

Tipping bucket rain gauges are designed to collect and record precipitation as it falls. They consist of the tipping bucket gauge and an event recorder.

As with other types of precipitation gauges, the tipping bucket gauge should be located in an opening greater than two but not more than five tree heights in diameter.

Installation of the Tipping Bucket Rain Gauge. Mount the tipping bucket rain gauge (Figure 9) on a WOODEN PLATFORM one metre by one metre square by ten centimetres thick.

Tighten the BASE of the tipping bucket gauge to the WOODEN PLATFORM with wood screws and lock washers. The screws should be three centimetres long and 0.7 cm diameter, and the lock washers should be 0.8 cm inside diameter. Level the tipping bucket rain gauge.

Enclose all electrical wiring leading from the gauge to the EVENT RECORDER in flexible metal electrical conduit. This is intended to protect the wires from damage by gnawing animals such as squirrels and porcupines.

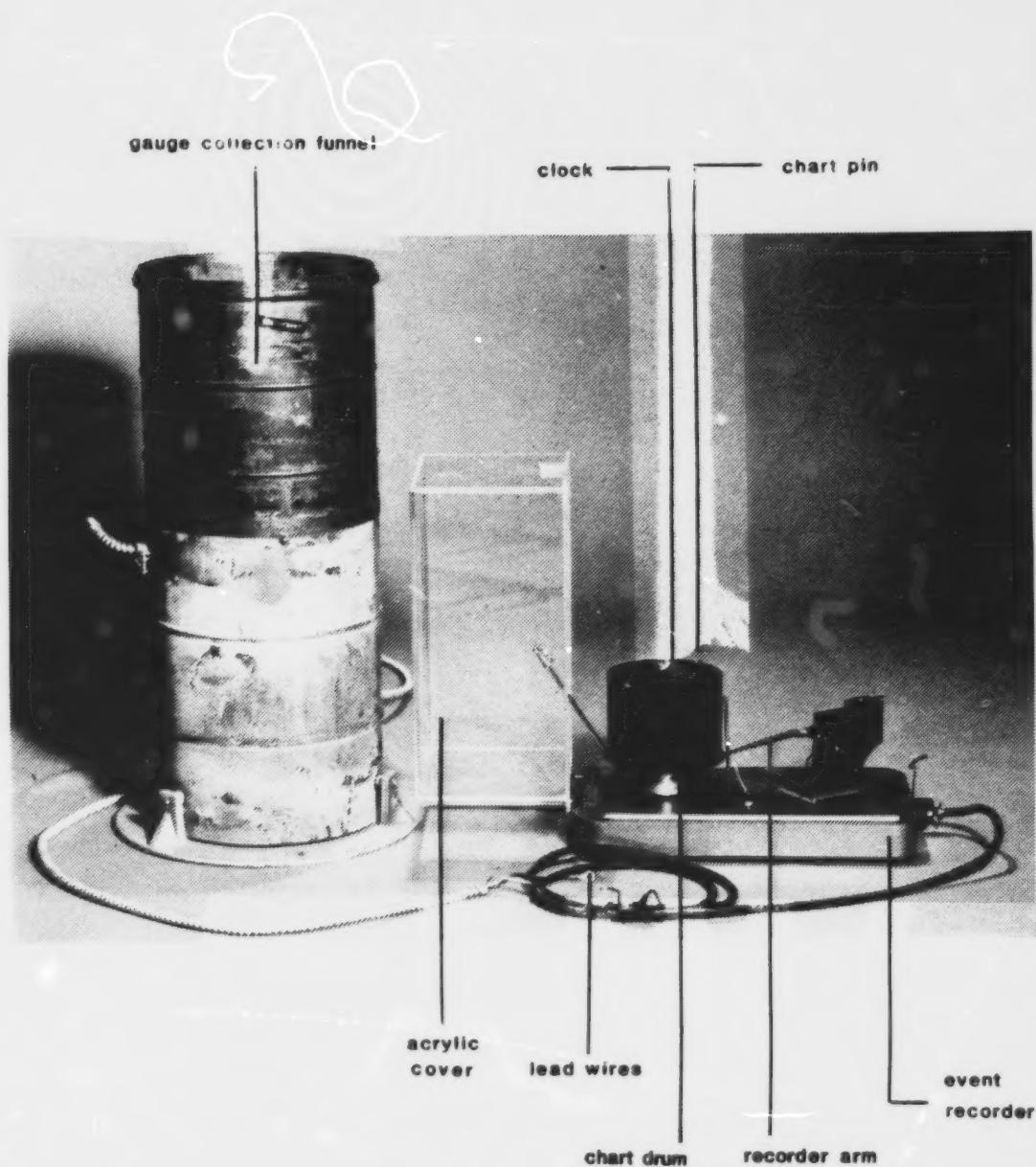


Fig. 9a. TIPPING BUCKET RAIN GAUGE.



Fig. 9b. TIPPING BUCKET RAIN GAUGE WITH COLLECTION FUNNEL REMOVED,

Connect the POSITIVE lead wire of the gauge with the NEGATIVE lead wire of the EVENT RECORDER, and then both of these wires to the POSITIVE terminal of a 7.5 volt battery. Connect the NEGATIVE lead wire of the gauge with the POSITIVE lead wire of the EVENT RECORDER, and then both of these wires to the NEGATIVE terminal of the 7.5 volt battery.

Enclose the battery and EVENT RECORDER in a STEVENS screen weather station enclosure, or in a galvanized steel shelter.

To change the chart:

1. Remove the CHART DRUM from the RECORDER.
2. Wind the CLOCK before replacing the CHART.
3. Lift the CHART PIN up to remove the old CHART.
4. Mark the station location, date and present time on the new chart.
5. Install a new CHART, making sure that the CHART is flushed against the bottom of the CHART DRUM.

6. Reinsert the CHART PIN and make sure that it is holding the CHART securely

7. Remove the tipping bucket GAUGE COLLECTOR FUNNEL.

8. Check the operation of the TIPPING BUCKET by manually tipping the bucket lever a few times to see if the recorder is recording the tips. If the recorder is functioning properly, mark "check" on the new CHART where the manual tipping was recorded. If the RECORDER is not functioning properly check the following:

A. The battery should be reading no less than 7.5 volts.

B. Make sure that the MAGNET is aligned properly so it can register the electrical signal from the TIPPING BUCKET. Adjust a SCREW located at the fulcrum of the TIPPING BUCKET LEVER for proper alignment of the magnet.

C. Check the RECORDER to see if the RECORDER ARM is moving. If it is not moving, replace the RECORDER as soon as possible.

4.3 Belfort Gauge

Stand Construction. The materials for setting up this stand include those required for the Sacramento Precipitation Gauge stand. In addition, the following are required.

One plywood platform of 1.9 cm plywood, 40.6 cm square. This platform must be painted once with primer, then with a white high gloss enamel.

One .95 cm by 7.6 cm lag bolt and lock washer.

Three threaded stock .8 cm diameter by 10.2 cm long brass bolts.

Three .8 cm plated lock washers.

Nine .8 cm plated flat washers.

Three .8 cm plated nuts.

Three .8 cm plated wing nuts.

Three spacers made from rigid copper pipe 2.5 cm long by 1.3 cm inside diameter.

Pre-Installation Assembly.

1. Drill a .95 cm hole through the center of the TRIPOD BASE and the PLYWOOD platform.
2. Attach the TRIPOD BASE to the PLYWOOD platform with the wood screws.

Installation. The Belfort Gauge is installed on its foundation by the following procedure, which is adapted from the Belfort Universal Recording Gauge operating manual:

1. Remove the COLLECTOR (Figure 10) by rotating it clockwise sufficiently to disengage the BAYONET LOCK, and then pulling it up and off of the GAUGE HOUSING.

NOTE: Use extreme care not to distort the area of the collector opening.

2. Remove the CATCH BUCKET. The CHART CYLINDER, RECORDING INK and DAMPING FLUID are shipped packed into the CATCH BUCKET.
3. Remove the SCREW (Figure 11), WASHER and BUCKET PLATFORM.

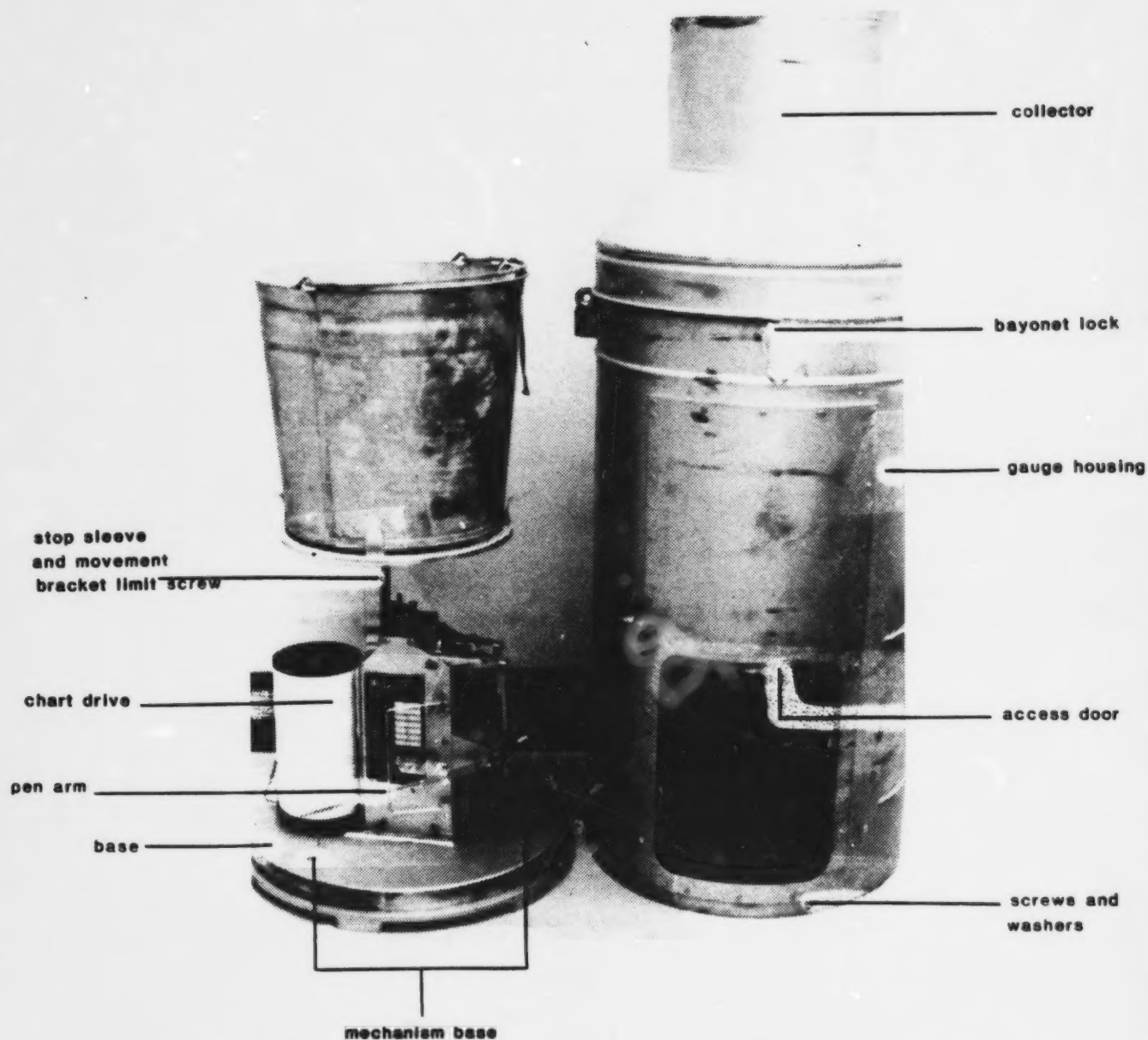


Fig. 10 UNIVERSAL RECORDING PRECIPITATION GAUGE,

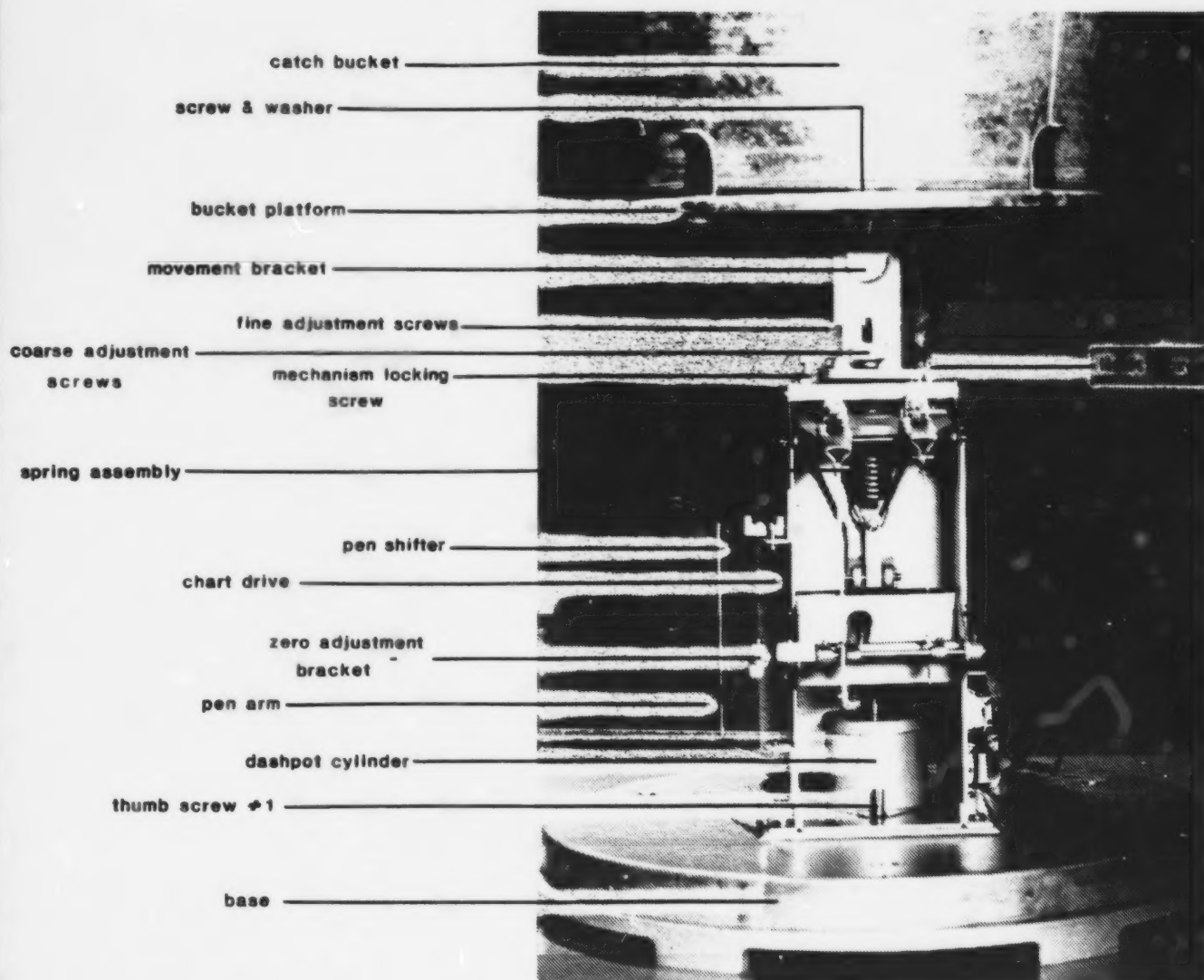


Fig. 11. RAIN GAUGE MECHANISM SINGLE SPRING.

4. Remove five SCREWS and WASHERS (Figure 10) and remove the GAUGE HOUSING from the BASE. Note the location of the sliding ACCESS DOOR relative to the CHART DRIVE and PEN ARM.

5. Three .95 cm diameter holes, 120° apart on a 27.3 cm diameter circle, are provided in the MECHANISM BASE for mounting it to the SUPPORT BASE or FOUNDATION.

Exercise extreme care when mounting the MECHANISM BASE. The Machined GAUGE HOUSING shoulder must be horizontal, and the base must not be distorted when it is mounted.

Hardware for mounting the MECHANISM BASE is not supplied with the gauge. However, hardware is supplied with the SUPPORT BASE for mounting it to the MECHANISM BASE. In addition, hardware is supplied with the SUPPORT BASE for mounting it to the FOUNDATION, or to assist in imbedding it in a concrete foundation.

6. Remove the SHIPPING TIE holding the PEN ARM to the PEN SHIFTER (Figure 11).

7. Loosen the MECHANISM LOCKING SCREW (Figure 11) and NUT. Back the SCREW out until the top LEVER is stopped by a LIMIT SCREW. Retract the LOCKING SCREW two more turns and then lock it in position with its NUT.

Remove the STOP SLEEVE (Figure 10) from around the MOVEMENT BRACKET LIMIT SCREW. Do not discard the STOP SLEEVE because it will be needed when the gauge is shipped again. Do not disturb the settings of the LIMIT SCREWS because their positions are a part of the gauge calibration.

8. Remove the wrapping from the CHART DRIVE MECHANISM, and unscrew the MECHANISM from the BASE.

9. The DASHPOT (Figure 12) is mounted to the MECHANISM BASE with two identical THUMBSCREWS (numbered 1 and 2 in the figure). Remove the THUMBSCREW numbered "2" in Figure 12, and loosen the other. Push up the DASHPOT COVER and pull the DASHPOT out from the MECHANISM FRAME.

10. Fill the DASHPOT CYLINDER with damping fluid from the bottle shipped in the CATCH BUCKET to within .3 cm of the DASHPOT CYLINDER rim. Replace the DASHPOT in the MECHANISM FRAME and tighten the two THUMBSCREWS.

Empty the CATCH BUCKET, setting aside the recording ink, and set the CATCH BUCKET on its PLATFORM. If the gauge is equipped with an overflow attachment place the OVERFLOW TUBE in the round hole in the PLATFORM. Center the OVERFLOW TUBE over the OVERFLOW FUNNEL mounted in the MECHANISM BASE.

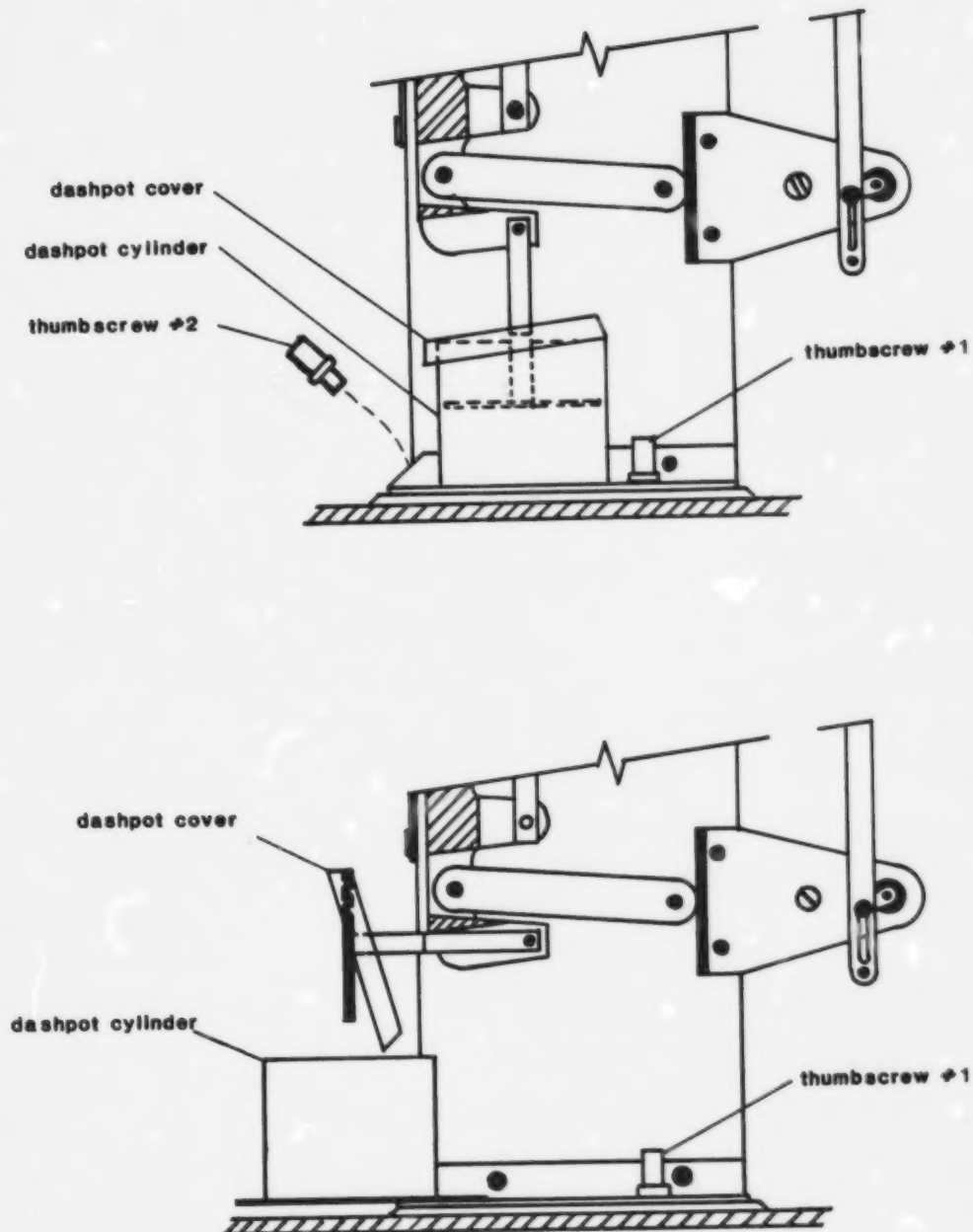


Fig. 12. REMOVAL OF DASHPOT.

11. Replace the CHART DRIVE MECHANISM. Make sure that the MOUNTING STUD of the CHART DRIVE MECHANISM is adjusted so that the WINDING KEY (of a spring-driven chart drive) or the MOVEMENT VIEWING PORT (of a battery-powered chart drive) are accessible from the sliding ACCESS DOOR of the GAUGE HOUSING.

Ensure that the MOUNTING STUD flange is firmly seated against its mounting surface, but do not over tighten the mechanism because this will disturb the setting of the MOUNTING STUD.

12. Remove the THUMBNUT from the CHART DRIVE MECHANISM SPINDLE. Mount the CHART CYLINDER with its CHART CLIP on the SPINDLE. Be careful to ensure that the CYLINDER GEAR meshes with the pinion gear of the DRIVE MECHANISM. Replace and tighten the THUMBNUT.

13. Replace the GAUGE HOUSING. Make sure it is positioned on the mechanism BASE so that the CHART DRIVE and PEN ARM are accessible through the sliding ACCESS DOOR.

14. Fasten the BUCKET PLATFORM to the MOVEMENT BRACKET with a screw and washer as shown in Figure 11. If the gauge is equipped with an OVERFLOW ATTACHMENT make sure that the round hole in the BUCKET PLATFORM is over the OVERFLOW FUNNEL in the MECHANISM BASE (Figure 13).

15. Replace the COLLECTOR on the GAUGE HOUSING. The procedure is the reverse of the removal procedure given in step 1. Staples are provided on both the COLLECTOR and the GAUGE HOUSING so that they can be padlocked together.

16. The GAUGE HOUSING and the sliding ACCESS DOOR are also provided with a sliding bolt and staple to take a padlock.

Operation. The following procedure should be followed when changing charts. Access is through the sliding access door in the gauge housing.

1. Open the sliding door and lightly touch the bucket platform to make a short vertical timecheck mark on the chart. If the chart drive has stopped turn the chart cylinder slightly in each direction to mark the present position of the pen. If the pen is not working mark the chart with a dot enclosed in a circle at the pen position.

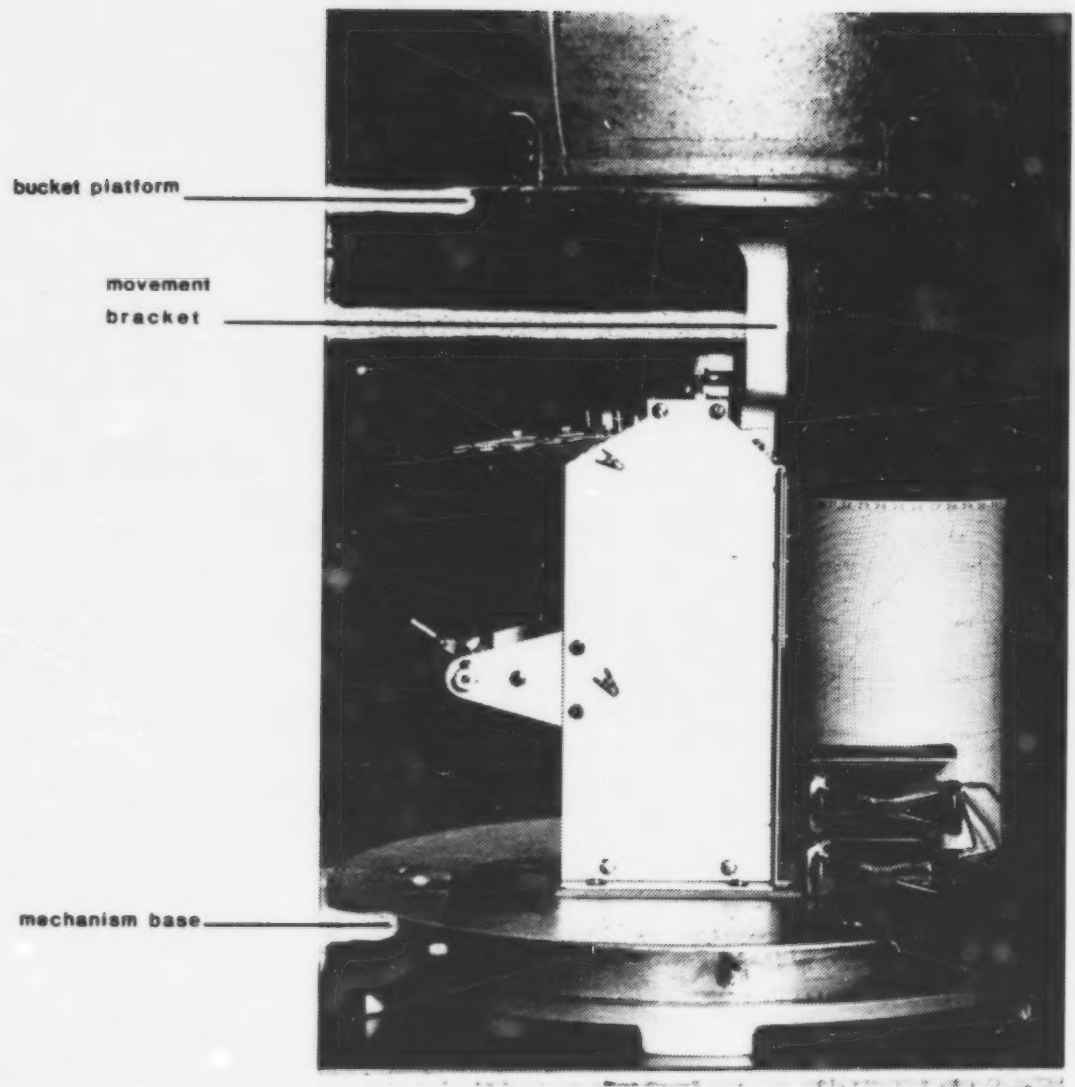


Fig. 13. RAIN GAUGE MECHANISM, REAR VIEW.

2. Lift the pen from the chart by moving the PEN SHIFTER shown in Figure 11 outward.
3. Remove the COLLECTOR. The CATCH BUCKET should only be emptied if it does not have antifreeze or oil in it to prevent freezing or evaporation. If the bucket must be emptied, directions for replacing antifreeze and oil are given under Gauge Winterizing.
4. Remove the chart cylinder thumbnut and lift the chart cylinder up and off the spindle. Take care not to smear the ink on the chart. Release the chart clip and remove the chart. Do not store the chart until the ink has dried.
5. Wind the chart drive if it is spring driven. No preparation for a new recording period is needed for battery powered recorders unless the battery needs replacement. The battery should be replaced every three months.
6. If the pen requires cleaning refer to the instruction book.

7. If the chart is the double tab type, mount a new chart as follows.

A. Fold the right hand tab under the back of the chart and wrap the chart snugly around the cylinder so the time is read from left to right, the corresponding graduations for the amount of rainfall meet, the bottom edge of the chart is against the cylinder flange, the folded end of the chart overlaps the opposite end and the crease in the fold is at the right hand edge of both the notch in the upper edge of the cylinder and the slot in the cylinder flange.

B. Place the clip inside the fold at the overlapping end of the chart, slip the straight end of the clamp into the slot in the cylinder and seat the bent end of the clamp in the notch in the upper cylinder edge.

8. If the chart is the single-tab type it is placed on the cylinder as follows.

A. Wrap the chart snugly around the cylinder so the time is read from left to right, the corresponding rainfall graduations meet, the bottom edge of the chart

is against the cylinder flange and the end of the chart without a tab is at the right-hand edge of both the notch in the upper edge of the cylinder and the slot in the cylinder flange.

B. Place the clip over the untabbed end of the chart, insert the straight end of the clip into the slot in the cylinder flange and place the bent end of the clip in the notch in the upper edge of the cylinder.

9. Replace the chart cylinder on the chart drive spindle. Be careful to make sure the pinion and cylinder gears mesh.

10. Refill the pen and push in the PEN SHIFTER to return the pen almost to the chart surface. Check that the pen indicates the proper level of fluid in the CATCH BUCKET. If it does not it should be adjusted using the coarse and fine adjustment screws (Figure 11).

Set the chart to the proper time by first turning the cylinder clockwise past the correct time, then turn it counterclockwise to the correct time. Be sure that the time is correctly set to morning (a.m.) or afternoon (p.m.).

11. Push the PEN SHIFTER all the way in to put the pen on the chart. Lightly touch the bucket platform to make a time check on the chart.

2 Gauge Winterizing. The gauge must be protected from freezing during the winter. The following procedure will protect the gauge:

1. Rotate the FUNNEL (Figure 10) fixed to the bottom of the collector until the FUNNEL BEAD clears the pins in the COLLECTOR TUBE and lift it off.

2. Remove the CATCH BUCKET and empty it. Replace it on the gauge and add an antifreeze solution of 950 ml of ethylene glycol and 1420 ml of methyl alcohol. Add 180 ml of Voltesso oil to the solution to prevent evaporation.

3. Do not make any adjustments to the gauge reading after adding the antifreeze and oil to the bucket. The gauge will read approximately 70 ml of precipitation.

4. Snow and ice will mix with the antifreeze and oil mixture by themselves in most instances.

When enough water has been collected the solution in the bucket may freeze. When dilution has progressed far enough to make freezing possible the bucket should be emptied and a new solution of antifreeze and oil placed in it. Table 1 shows the freezing point for various gauge readings.

TABLE 1
FREEZING POINTS RELATED TO GAUGE LEVELS

Gauge Level in Cm	Centigrade Freezing Temperature
15.2	-40
17.8	-30
20.3	-23
25.4	-13
30.5	-4

Maintenance. In general, frequency of gauge servicing will depend upon the operating environment. It may need service as often as every three months in dusty environments, but only once a year under optimum conditions. The need for gauge servicing should be evaluated during regular operational visits. The following recommendations should be observed:

1. Clean all moving parts with a soft brush moistened with varsol. Solvents that attack paint should never be used because they would destroy the protective coating of the gauge.
2. No part of the mechanism except the chart drive should ever be oiled, and oil should be used sparingly on the drive mechanism. Corrosion resistant materials have been used throughout the gauge, and oil will become gummy in time and interfere with the gauge operation.
3. Examine the weighing mechanism linkage for evidence of excessive friction. If it is necessary to disassemble this linkage for repair the gauge must be recalibrated.

4. Clean the bucket thoroughly. If foreign material is allowed to accumulate in the bucket the weight may become too great to be compensated by the zero adjustment.

5. Inspect the DASH POT and add silicone fluid if needed so the PISTON is covered when it is in the uppermost position, e.g. when the gauge reading is zero.

6. Clean the PEN according to the directions in the instruction manual for the gauge.

7. Inspect and service the CHART DRIVE MECHANISM if necessary, following the instructions in the gauge instruction manual.

8. Recalibration of the gauge may be done by the factory, or procedures given in the gauge instruction manual may be followed.

1.4.4 Precipitation Information Agencies

Other agencies in Alberta are involved in collection of climatic data. Some of these are the Alberta Forest Service Weather Section, the Climate Unit of Resource Evaluation and Planning, Alberta Environment Technical Services Division and the Atmospheric Environment Service of Environment Canada.

Any usable standard data collected regularly by watershed personnel should be submitted to Resource Evaluation and Planning (REAP) of Alberta Forestry, Lands and Wildlife for publication to make them available to other users.

GENERAL REFERENCES

- American Public Health Association, American Water Wastes Association, and Water Pollution Control Federation, 1980. Standard Methods for the Examination of Water and Wastewater. 15th edition. American Public Health Association, New York. 874p.
- Gray, D. M. and Male, D. H. Editors. 1981. Handbook of Snow: Principles, Processes, Management and Use. Pergamon Press.
- Herschy, R., 1970 The Magnitude of Errors at Flow Measurement Stations. Vol. 1. Proceedings, Symposium on Hydrometry, Koblenz. Sept. 1970. pp. 109- 131. IAHS Paris Publication No. 89.
- International Organization for Standardization. 1981. Liquid Flow Measurement in Open Channels - Part 1: Establishment and Operation of a Gauging Station. ISO 1100/1-1981 (E).
- United States Department of the Interior, Geology Survey. 1977. National Handbook of Recommended Methods for Water-Data Acquisition. Reston, V.A.



ALBERTA FOREST SERVICE WATERSHED MANAGEMENT

FIELD AND LABORATORY METHODS

PART 2

MEASUREMENT OF STREAMFLOW

by

A.M.-K. Nip and R.A. Hursey



TABLE OF CONTENTS

GENERAL INTRODUCTION	1
1. Introduction	2
2. Safety Considerations	2
1.1 General Precaution	2
1.2 Ice Covered Streams	3
3. Quality Control	4
4. Equipment List	5
4.1 Velocity-Area Sites: Wading Technique ...	5
4.2 Velocity-Area Sites: Measurement Through Ice	6
5. Preparation for Field Work	9
5.1 Equipment Check	9
Current Meter	9
Testing the Beeper	11
6. Field Procedure	14
6.1 General Notes	14
6.2 Streamflow Measurement by the Velocity-Area Technique	15
Choosing the Measurement Location	16

Taking the Current Measurement	17
6.3 Streamflow Measurement Under Ice by the Velocity-Area Technique	27
Ice Safety	27
7. Analysis and Reporting	30
7.1 Calculation of Total Stream Discharge	30
7.2 Calculation of Hydrometric Survey Notes ...	31
7.3 Calculation of Total Discharge by Computer Program	34
7.4 Reporting	35
8. Cleanup and Storage	38
9. Stage-Discharge Relationship	40
9.1 Introduction	40
9.2 Definition of Stage	40
9.3 Factors Affecting Natural Stage-Discharge Relationships	40
9.4 Methods of Measuring the Stage	42
Manual Observation	42
Automatic Continuous Recorders	46
9.5 Stream Flow Information Agencies	61
GENERAL REFERENCES.....	62

LIST OF ILLUSTRATIONS

Figure	Page
1. Exploded View of Bucket Wheel Assembly.....	10
2. Adjusting Depth of Current Meter.....	12
3. HYDROMETRIC SURVEY NOTES	21
4. Example of Current Meter Rating Table.....	25
5. Completed HYDROMETRIC SURVEY NOTES.....	32
6. Example of Computer Printout of Streamflow Data using program HSNRP2.....	36
7. Example of Computer Printout of Streamflow Data.	37
7a. Using Program QCALC.....	37a
8. Staff Gauge.....	43
9. Crest Gauge.....	44
10. Components of a Stream Gauging Station.....	47
11. Stilling Well Installation.....	50
12. Water Level Recording Assembly.....	52
13. Exploded View of Recorder.....	53
13a. Exploded Side View of Recorder	54
14. Stevens Level Recorder Charts.....	57



GENERAL INTRODUCTION

The collection of hydrometric, water quality and hydrometeorologic information is a complex task. A variety of instruments and measurement methods are required to produce a record of hydrologic inputs and outputs for a watershed basin.

There is a growing awareness and recognition that standardization of data acquisition methods is required to ensure data comparability, and to allow comparison of data analyses.

To ensure acceptable quality of data, agreement must be reached among the operating, contributing and user agencies on methods to be used in measuring and sampling data. The purpose of this manual is to assist those involved in the field of data acquisition by outlining methods, practices and instruments which are reliable and recognized by the International Organization for Standardization.

1. INTRODUCTION

The purpose of measuring streamflow is to find out how much water is carried by the stream at the point where the measurement is taken. The quantity of water produced by a watershed is of the utmost importance to the watershed manager in meeting demands of on-site and downstream users. In addition, the quantity of water is the baseline to which all water quality data must be related.

Two different types of streamflow measurements are discussed in this volume: direct measurement using a velocity-area technique, both for wading in open streams and for measuring through ice; and indirect measurements using non-recording and recording gauges.

2. SAFETY CONSIDERATIONS

2.1 General Precautions

ALTHOUGH IMPORTANT, STREAMFLOW MEASUREMENTS ARE NOT WORTH THE RISK OF LIFE OR INJURY.

Collecting streamflow measurements should be considered potentially dangerous at all times. This is especially true

when sampling through ice, in swift water, or in water too muddy or turbid to see the bottom clearly at all times. As a general rule streamflow measurement should only be done when at least two people are present. Each, in case of mishap, should be strong enough to pull the other from the stream with rope techniques similar to those used in mountaineering.

2.2 Ice-Covered Streams

NEVER WALK ON ICE WITHOUT MAKING SURE IT IS SAFE TO DO SO.

Sampling ice-covered streams is particularly hazardous. Flowing water under ice can erode the underside of the ice, especially where the current is strong or there is an upwelling. Because of this the ice in the stream channel may be much weaker than the ice next to the banks, although there may be no visible change to the surface appearance of the ice. If ice is covered with snow the surface is, of course, not visible. There may even be open water flowing under a snow bridge.

Therefore, when proceeding onto an ice surface the thickness of the ice must be tested by a sharp blow from an ice chisel before it is walked on, and this must be repeated step-by-step as you proceed. Snow-covered surfaces must be probed even if they are a few feet from the direct line of travel to ensure

that open water does not adjoin apparently solid ice. Open water greatly weakens the bearing capacity of adjoining ice even though the ice may seem solid when struck with the ice chisel.

3. QUALITY CONTROL

As with any scientific procedure, streamflow measurements must be made with care and precision if they are to be of any use. However, the actual conditions encountered in field work are not likely to be exactly what is assumed in the procedures manual. Therefore, the judgment of the person doing the work must be reliable.

The single most important consideration of quality control is to conduct the procedures exactly as described. If, for any reason the procedures are not followed exactly, it is critical to make detailed notes of what was done differently from the specified procedures. With adequate notes the data analyst can usually compensate for the problems which arose in the field by using the appropriate analysis.

Without adequate notes the data analyst will be unable to evaluate inconsistent data, and the reliability of the person taking the sample will come into question.

4. EQUIPMENT LIST

Before going to the field the following equipment lists must be checked and the time taken to ensure that all the necessary items are in good working order and available in sufficient quantities to complete the work. Failure to do this may result in wasted time and effort.

4.1 Velocity-Area Sites: Wading Technique

Recording Forms. HYDROMETRIC SURVEY NOTES

Current Meter. Record type (Pygmy or Price 622AA) and serial number.

Wading Rod. A metric self-adjusting rod is required to establish the correct water depth for measuring mean current velocity.

Location Stakes. Metal stakes to permanently mark the starting and ending points of the stream cross-section transects.

Tape Measure. A metric unit tape at least 20 m long, with one centimetre graduations, to stretch across the stream.

Current Meter Rating Table. The current meter rating table which is calibrated to the particular current meter in use must be the one used for calculations.

Stop Watch. An accurate stop watch capable of recording to the nearest half second is required to time current measurements.

Safety Line and Harness. A safety line and harness for the person wading which is adequate to allow him to be pulled from the stream by the others in the party if he becomes incapacitated. This equipment should include adequate anchoring devices, pulley systems and a personal floatation device, and must always be used when sampling under potentially dangerous conditions.

4.2 Velocity-Area Sites: Measurement Through Ice

Recording Forms. HYDROMETRIC SURVEY NOTES.

Current Meter. Record type (Pygmy or Price 622AA) and serial number.

Location Stakes. Metal stakes to permanently mark the starting and ending points of the stream cross-section transects.

Tape Measure. A metric unit tape at least 20 m long, with one centimetre graduations, to stretch across the stream.

Current Meter Rating Table. The current meter rating table which is calibrated to the particular current meter in use must be the one used for calculations.

Stop Watch. An accurate stop watch capable of recording to the nearest half second is required to time current measurements.

Metre stick. A metre stick of sufficient length to measure the water and ice depth across the stream profile is required.

Safety Line and Harness. A safety line and harness for the person working on the ice which is adequate to allow him to be pulled from the stream and across the ice if he should break through the ice. This equipment should include adequate anchoring devices, pulley systems and a personal flotation device, and must always be used when working in dangerous ice conditions.

Ice Chisel. An ice chisel appropriate to chop holes in the ice for making current measurements and water level measurements.

Strainer. Used to remove ice chunks floating in the holes chopped in the ice.

Ice Auger and Fuel. The ice auger is used to drill holes through the ice. Use caution at all times when using the auger.

Dry Clothing. A change of dry clothing for anyone working on the ice or otherwise subject to wetting should be available to help prevent hypothermia. Insulated coveralls and woolen socks are excellent for this purpose.

5. PREPARATION FOR FIELD WORK

Before going to the field to make stream measurements proper preparation must be made to ensure that the time in the field will not be wasted making repairs or adjustments.

2.5.1 Equipment Check

Depending on the type of measurements to be made, the appropriate Equipment List in Section 4 should be consulted. All equipment on the list must be examined for condition and any necessary replacement, repairs and adjustments made.

Current Meter. For the current meter to function properly the bearing surfaces must be in good order. To check, loosen the BUCKET WHEEL RAISING NUT (Figure 1) by holding the BUCKET WHEEL RAISING NUT tightly and rotating the BUCKET WHEEL gently counter-clockwise. Continue to loosen the BUCKET WHEEL RAISING NUT until the BUCKET-WHEEL SHAFT rests on the PIVOT load bearing surface.

Gently rotate the bucket wheel until it comes to a stop. If it comes to a gradual stop, the BUCKET-WHEEL SHAFT and the PIVOT load bearing surface are in satisfactory condition for use. Tighten the BUCKET WHEEL RAISING NUT to the proper tension.

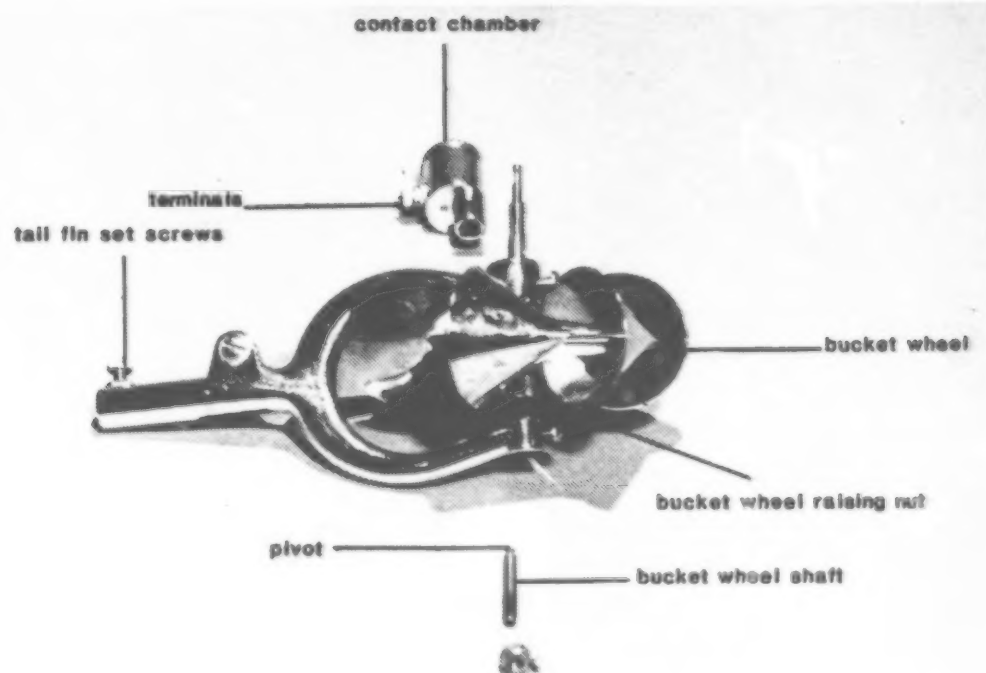


Fig. 1. EXPLODED VIEW OF BUCKET WHEEL ASSEMBLY.

Tension should be adjusted so the BUCKET WHEEL RAISING NUT is tight enough to prevent the BUCKET WHEEL from rotating with slight pressure applied.

If the BUCKET WHEEL comes to an abrupt stop the BUCKET WHEEL SHAFT and the PIVOT load bearing surface should be cleaned with a soft lint-free cloth and closely inspected for wear. If there is evidence of wear, reassemble the unit and send it for recalibration. If there is no evidence of wear, test the BUCKET WHEEL rotation again as described above. If it again comes to an abrupt stop send the unit for repair.

Testing the Beeper. Connect the ELECTRICAL LEAD on the WADING ROD to one of the TERMINALS on the current meter CONTACT CHAMBER (Figures 1 and 2). There are two TERMINALS available to choose from depending on the velocity of the stream. Under most conditions the TERMINAL labelled "1" for singular rotational counts is used.

When working in extremely fast-flowing streams where there might be difficulty in counting the number of beeps or clicks, the TERMINAL labelled "5" may be used. In this case a beep will be heard for every five complete rotations of the BUCKET WHEEL.

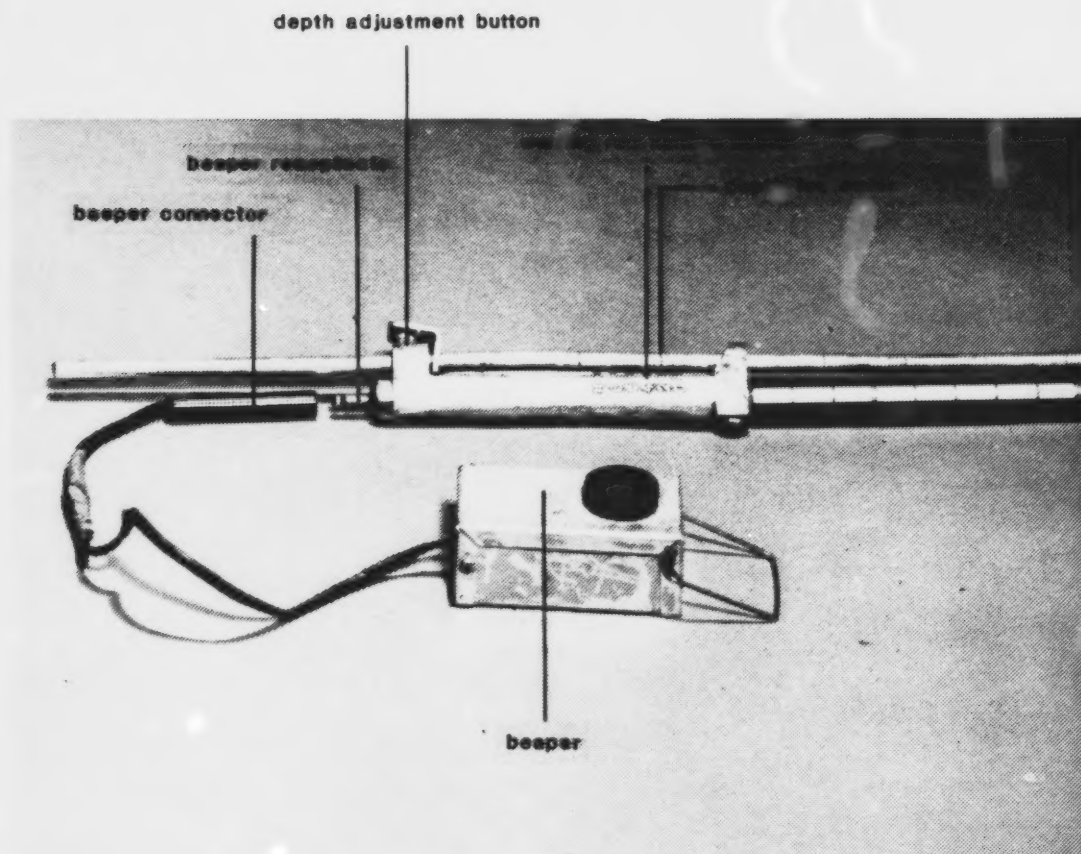


Fig. 2. ADJUSTING DEPTH OF CURRENT METER

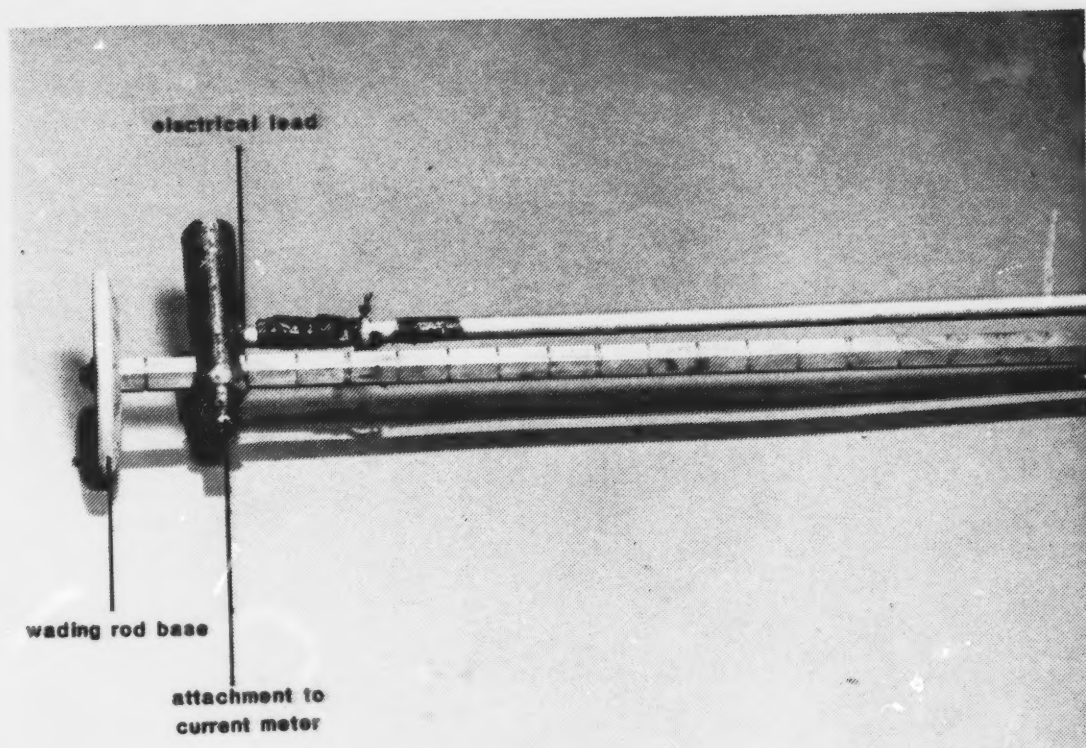


Fig. 2. ADJUSTING DEPTH OF CURRENT METER.

Loosen the BUCKET WHEEL RAISING NUT. Attach the BEEPER to the BEEPER RECEPTACLE at the HANDLE of the WADING ROD (Figure 2).

Gently rotate the BUCKET WHEEL. A series of sharp clicks or beeps (depending on the type of BEEPER used) should be heard. If nothing is heard, check all connections and the condition of the battery, and check again for beeps or clicks. If repairs are required they should be done immediately.

Packing. Pack all equipment carefully in custom fitted cases for transport to the field site to ensure that nothing is damaged in transit.

6. FIELD PROCEDURE

6.1 General Notes

Measurements on streams should always be made at the same location and referenced to the same initial point of the shore. This initial point should be permanently marked and, in addition, referenced by triangulation to other notable landmarks.

Each time a stream measurement site is visited careful notes must be taken which describe the general conditions of the site and the upstream and downstream areas. These notes are to include everything that could affect streamflow measurements.

Look for and describe such conditions as debris jams, beaver activity and weed growth near the gauging station or proposed current measuring site. When encountering such conditions remove the debris jam, beaver dam or weed growth. Describe the conditions before and after the changes. Whenever possible avoid such conditions when choosing a site.

If the flow level of the stream appears high look for overflow channels. Note the deposition of gravel, the development of sand bars in the vicinity of the gauging station or current measuring site, and overflow markings on stream

channels or on vegetation.

During winter a description of ice conditions, the amount of ice cover, ice jams and overflowing of the ice should be noted along with any other evidence of changes in stream flow such as subsidence of the old ice.

These general notes are of equal if not greater importance than the quantitative data collected. The completeness of the notes will not only aid in making judgment decisions when computing and analysing records, but can be of value for detailed studies at a future date.

It is especially important that careful notes be made of any difficulties encountered in collecting the data and a careful explanation included about how difficulties were overcome. From this information the procedures can be evaluated for possible improvement in future work.

6.2 Streamflow Measurement by the Velocity-Area Technique

This method is based on calculation from the cross-sectional area of the flowing water and the average velocity of flow. Its validity is dependent upon accurate measurement of the stream cross-section and the velocity of the current.

To obtain an acceptable level of accuracy the following

procedures have been developed and they must be carefully followed in the field.

Choosing the Measurement Location. Because repeated measurements of streamflow made by this technique should always be taken along the same cross-sectional transect, the initial choice of location must be made with careful attention to detail. The following factors recommended by the International Organization for Standardization (1981) have to be taken into account.

1. The location should be in a reach of the stream where the bed and the banks are straight and uniform for a distance of approximately five times the width of the stream in the upstream direction, and approximately twice the width of the stream in the downstream direction. The stream should be at least two metres wide at the sampling location. A pygmy current meter should be used for narrower streams.
2. The actual cross-section of the streambed where the sampling transect will be made should be as uniform as possible and free from protruding large rocks. Remove any such rocks before establishing the transect and make sure that the water exhibits essentially uniform flow in the area where measurement will be made.
3. The measurement area should be chosen where there is

little or no evidence that the stream has escaped its channel during high water flow periods.

Taking the Current Measurement.

1. Establish an initial point on the bank of the stream. This is the location to which all measurements will be referred.

A. The initial point should be located so that the cross-sectional transect will be at right angles to the direction of streamflow.

B. The initial point and final point should be marked by a permanent object, such as a metal stake, to which a measuring tape can be firmly attached.

C. The initial and final points should be above any area which can reasonably be expected to be flooded.

D. The distances and bearings of at least two prominent landmarks should be recorded in relation to the initial point so it can be relocated if necessary.

2. Anchor one end of the tape measure to the initial point and stretch it tightly across the stream to the opposite bank at right angles to the stream flow. The tape must be

suspended above the water and securely anchored on the opposite bank.

3. Vertical projections must be made from the tape measure to the streambed to establish where the current meter will be located for sampling. A number of factors must be considered when deciding on the placement of these verticals.

A. The amount of water flowing past the current meter at any subsection should not exceed 10 percent of the total measured current flow.

B. The cross-sectional transect of the stream is divided into a number of subsections within which the current is measured. The optimum number of subsections is about 20. Consideration of the contribution made to experimental error due to the number of verticals is discussed in detail by Herschy (1970). His findings indicate that for any number of verticals less than 10 the error is unacceptable, and that the reduction of error by having more than 15 verticals is negligible.

Also, when more than 15 current readings are obtained, the streamflow may change significantly during the time required to take the measurements. The

result is that unknown error may be introduced which can offset any gain in the precision of the measurement.

C. The distance between verticals, which defines the subsection, cannot be less than the width needed for the current meter to operate without overlapping of subsections. This distance is .15 m for the Price 622 Current Meter.

D. The variability of water depth along the stream cross-sectional transect requires that the verticals must be more closely spaced.

E. The verticals must be more closely spaced when current velocities are more variable.

F. The verticals must be more closely spaced in narrow streams than in wider streams.

G. The minimum duration of streamflow measurement in any subsection is 40 seconds. It must always be kept in mind that there are continuous fluctuations in streamflow in most streams, so that the longer the time required to complete the sampling across the stream the lower the accuracy of the results.

4. Taking into account all the above considerations for the number and placement of metering subsections and the duration of observation, decide on the placement of the verticals. Record the measured distance from the initial point to each of the verticals on the data sheet HYDROMETRIC SURVEY NOTES (Figure 3).

5. Record the station location, date, time of measurement, stage level, weather conditions and type and serial number of the current meter on the data sheet HYDROMETRIC SURVEY NOTES.

6. Attach the CURRENT METER to the WADING ROD (Figure 2) and tighten the TAIL FIN SET SCREW (Figure 1) with a screwdriver. The CURRENT METER must be attached to the WADING ROD so that it is exactly perpendicular to the axis of the WADING ROD in order to obtain accurate readings. The positioning of the CURRENT METER in relation to the WADING ROD must be checked before each measurement. The tail fins should be attached when stream depths are greater than 0.3 m.

7. Connect the ELECTRICAL LEAD on the WADING ROD to one of the TERMINALS on the current meter CONTACT CHAMBER (Figure 2).

STATION

Fig. 3. Hydrometric survey notes

8. Attach the BEEPER to the BEEPER RECEPTACLE at the HANDLE of the WADING ROD (Figure 2).

9. Loosen the BUCKET WHEEL RAISING NUT (Figure 1).

10. Gently rotate the BUCKET WHEEL (Figure 2). A series of sharp click or beeps (depending on the type of BEEPER used) should be heard. If nothing is heard, check all connections and check again for beeps or clicks. If no beeps or clicks can be heard, substitute a spare BEEPER and test it again.

11. Check that the safety harness and the rest of the rescue equipment is properly attached and in working order.

NOTE: If water quality samples are required these must be taken before proceeding with a streamflow measurement.

12. Move to the edge of the water and record the STARTING TIME and the distance to the edge of the water from the initial point (the permanent stake above the flood stage) on the HYDROMETRIC SURVEY NOTES (Figure 3).

13. Enter the water on the downstream side of the tape measure used to establish the placement of the verticals.

The person making the current meter readings must always stand downstream and to one side of the current meter when using it to minimize the influence on the current meter reading.

14. Move to a position closest to the edge of the water where there is a perceptible current (one which can be measured by the current meter).

15. Record the distance from the initial point on the HYDROMETRIC SURVEY NOTES. Record whether you are starting from the left or right bank looking downstream.

16. Measure the depth of the water using the wading rod at the first vertical and record on the HYDROMETRIC SURVEY NOTES. This is done by reading the depth of water flowing at right angles to the depth scale marked on the hexagonal shaft of the wading rod. Most wading rods are marked in metric units, thus the distance between each single line on the hexagonal shaft is 0.02 m, between double lines is 0.1 m and between triple lines is 0.5 m.

17. Position the CURRENT METER on the WADING ROD so that the reading will be taken at 60 per cent of the depth of water, as measured from the water surface.

This is done by depressing the DEPTH ADJUSTMENT BUTTON (Figure 2) located near the top of the WADING ROD, then moving the round shaft of the wading rod up or down until the DEPTH INDICATOR on the SCALE on the WADING ROD matches the depth of the water. Markings on the round shaft indicate the first decimal place of the depth of water and the markings on the handle of the wading rod indicate the second decimal place of the depth of water.

Example: If the depth of water is .36 metres, then the line marked with a "3" on the round shaft must line up with the "6" marked on the handle of the wading rod. Release the DEPTH ADJUSTMENT BUTTON and make sure that the CURRENT METER is perpendicular to the WADING ROD.

18. Place the WADING ROD vertically in the stream and make sure that the CURRENT METER is parallel to the direction of current flow.

19. Before starting the measurement of the current velocity allow the CURRENT METER to adjust to the current velocity being measured. This adjustment period is especially important at low velocities.

IMPORTANT NOTE: The number of revolutions of the CURRENT

METER which are to be recorded should be one of the fourteen listed in the calibrated Current Meter Rating Table (Example in Figure 4): e.g. 2, 5, 10, 15, 20, 30, 40, 50, 60, 80, 100, 150, 200, 250). The time during which the current is measured must be recorded to the nearest half second.

20. Using the stop watch, observe the current velocities for between 40 and 80 seconds. Record the time to the nearest half second, and the number of revolutions of the current meter, on the HYDROMETRIC SURVEY NOTES (Figure 3).

21. Repeat steps 14 through 20 of this procedure until the current velocity has been recorded at each of the chosen verticals across the entire stream cross-sectional transect. Remember that it is important to complete measurement of current velocities across the entire stream in as short a time as possible because streamflow may fluctuate over even short periods of time. Record the finishing time on the HYDROMETRIC SURVEY NOTES in the space provided.

22. Once all the measurements have been taken disassemble the equipment, except for the stakes at the initial and final points. Dry the equipment if possible and carefully pack it for return to the storage facility where it must be dried, cleaned, tested and placed in a proper storage area.

Environment Canada National Calibration Service																	
Meter number		ENR-16															
		Calibration date MARCH 14, 1984															
		Velocity in Metres/Sec = .5678 X rev/sec + .0102															
REV =>		2	5	10	15	20	30	40	50	60	80	100	150	200	250	<= REV	
40	0.044	0.094	0.177	0.261	0.344	0.511	0.678	0.845	1.012	1.346	1.680	2.315	3.350	4.185	4.0		
	0.043	0.093	0.175	0.258	0.340	0.505	0.670	0.835	1.000	1.330	1.659	2.484	3.308	4.133			
41	0.043	0.092	0.173	0.255	0.336	0.499	0.662	0.825	0.989	1.313	1.639	2.454	3.268	4.083	41		
	0.042	0.091	0.171	0.252	0.332	0.493	0.654	0.815	0.975	1.298	1.620	2.424	3.229	4.034			
42	0.042	0.090	0.169	0.249	0.328	0.487	0.646	0.805	0.964	1.282	1.600	2.396	3.191	3.986	42		
	0.042	0.089	0.167	0.246	0.325	0.482	0.639	0.796	0.953	1.267	1.582	2.367	3.153	3.939			
43	0.041	0.088	0.166	0.243	0.321	0.476	0.632	0.787	0.942	1.253	1.563	2.340	3.117	3.893	43		
	0.041	0.087	0.164	0.241	0.317	0.471	0.624	0.778	0.931	1.239	1.546	2.313	3.081	3.849			
44	0.041	0.086	0.162	0.238	0.314	0.466	0.617	0.769	0.921	1.225	1.528	2.287	3.046	3.805	44		
	0.040	0.085	0.160	0.235	0.310	0.460	0.611	0.761	0.911	1.211	1.511	2.262	3.012	3.762			
SEC																	
45	0.040	0.084	0.159	0.233	0.307	0.455	0.604	0.752	0.901	1.198	1.484	2.237	2.979	3.721	45		
	0.040	0.084	0.157	0.230	0.304	0.451	0.597	0.744	0.891	1.185	1.478	2.212	2.945	3.680			
46	0.039	0.083	0.155	0.228	0.301	0.446	0.591	0.736	0.881	1.172	1.462	2.188	2.914	3.640	46		
	0.039	0.082	0.154	0.226	0.297	0.441	0.585	0.728	0.872	1.159	1.447	2.165	2.883	3.601			
47	0.039	0.081	0.152	0.223	0.294	0.437	0.578	0.721	0.863	1.147	1.431	2.142	2.852	3.563	47		
	0.038	0.081	0.151	0.221	0.291	0.432	0.573	0.713	0.854	1.135	1.416	2.118	2.822	3.525			
48	0.038	0.080	0.149	0.219	0.288	0.428	0.567	0.706	0.845	1.123	1.402	2.097	2.793	3.489	48		
	0.038	0.079	0.148	0.217	0.286	0.423	0.561	0.699	0.838	1.112	1.387	2.076	2.764	3.453			
49	0.037	0.078	0.147	0.215	0.283	0.419	0.555	0.692	0.828	1.101	1.373	2.055	2.736	3.418	49		
	0.037	0.078	0.145	0.213	0.280	0.415	0.550	0.685	0.820	1.090	1.359	2.034	2.709	3.383			
SEC																	
50	0.037	0.077	0.144	0.211	0.277	0.411	0.545	0.678	0.812	1.079	1.346	2.014	2.682	3.350	50		
	0.037	0.076	0.142	0.209	0.275	0.407	0.539	0.671	0.804	1.068	1.333	1.994	2.655	3.317			
51	0.036	0.076	0.141	0.207	0.272	0.403	0.534	0.665	0.798	1.058	1.320	1.975	2.629	3.284	51		
	0.036	0.075	0.140	0.205	0.270	0.399	0.529	0.659	0.788	1.048	1.307	1.956	2.604	3.252			
52	0.036	0.074	0.139	0.203	0.267	0.395	0.524	0.652	0.781	1.038	1.295	1.937	2.579	3.221	52		
	0.036	0.074	0.137	0.201	0.265	0.392	0.519	0.646	0.774	1.028	1.282	1.918	2.555	3.191			
53	0.035	0.073	0.136	0.199	0.262	0.388	0.514	0.640	0.766	1.018	1.270	1.900	2.531	3.161	53		
	0.035	0.073	0.135	0.197	0.260	0.385	0.510	0.634	0.759	1.009	1.259	1.883	2.507	3.131			
54	0.035	0.072	0.134	0.196	0.258	0.381	0.505	0.629	0.752	1.000	1.247	1.865	2.484	3.102	54		
	0.035	0.071	0.133	0.194	0.255	0.378	0.500	0.623	0.746	0.991	1.236	1.848	2.461	3.074			
55	0.034	0.071	0.132	0.192	0.253	0.375	0.496	0.617	0.739	0.982	1.225	1.832	2.439	3.046	55		
	0.034	0.070	0.131	0.191	0.251	0.371	0.492	0.612	0.732	0.973	1.214	1.815	2.417	3.019			
56	0.034	0.070	0.129	0.189	0.248	0.368	0.487	0.607	0.726	0.964	1.203	1.799	2.396	2.992	56		
	0.034	0.069	0.128	0.188	0.247	0.365	0.483	0.601	0.719	0.956	1.192	1.783	2.374	2.966			
57	0.034	0.069	0.127	0.186	0.245	0.362	0.479	0.596	0.713	0.948	1.182	1.768	2.354	2.940	57		
	0.033	0.068	0.126	0.184	0.243	0.359	0.475	0.591	0.707	0.939	1.172	1.753	2.333	2.914			
58	0.033	0.068	0.125	0.183	0.241	0.356	0.471	0.586	0.701	0.931	1.162	1.738	2.313	2.889	58		
	0.033	0.067	0.124	0.181	0.239	0.353	0.467	0.581	0.695	0.924	1.152	1.723	2.294	2.864			
59	0.033	0.067	0.123	0.180	0.237	0.350	0.463	0.576	0.689	0.916	1.142	1.708	2.274	2.840	59		
	0.033	0.066	0.122	0.179	0.235	0.347	0.459	0.571	0.684	0.908	1.133	1.694	2.255	2.817			
SEC																	
60	0.032	0.066	0.122	0.177	0.233	0.344	0.455	0.567	0.678	0.901	1.123	1.680	2.237	2.793	60		
	0.032	0.065	0.121	0.176	0.231	0.341	0.452	0.562	0.673	0.893	1.114	1.666	2.218	2.770			
61	0.032	0.065	0.120	0.174	0.229	0.339	0.448	0.558	0.667	0.886	1.105	1.653	2.200	2.747	61		
	0.032	0.065	0.119	0.173	0.227	0.336	0.445	0.553	0.662	0.879	1.096	1.639	2.182	2.725			
62	0.032	0.064	0.118	0.172	0.226	0.333	0.441	0.549	0.657	0.872	1.087	1.626	2.165	2.703	62		
	0.032	0.064	0.117	0.170	0.224	0.331	0.438	0.545	0.651	0.865	1.079	1.613	2.147	2.682			
63	0.031	0.063	0.116	0.169	0.222	0.328	0.434	0.540	0.646	0.858	1.070	1.600	2.131	2.661	63		
	0.031	0.063	0.115	0.168	0.221	0.326	0.431	0.536	0.641	0.852	1.062	1.588	2.114	2.640			
64	0.031	0.062	0.115	0.167	0.219	0.323	0.428	0.532	0.636	0.845	1.054	1.576	2.097	2.619	64		
	0.031	0.062	0.114	0.166	0.217	0.321	0.424	0.528	0.632	0.839	1.046	1.563	2.081	2.599			
SEC																	
65	0.031	0.062	0.113	0.164	0.216	0.318	0.421	0.524	0.627	0.832	1.038	1.552	2.065	2.579	65		
	0.031	0.061	0.112	0.163	0.214	0.316	0.418	0.520	0.622	0.826	1.030	1.540	2.050	2.559			
66	0.030	0.061	0.111	0.162	0.213	0.314	0.415	0.516	0.617	0.820	1.022	1.528	2.034	2.540	66		
	0.030	0.060	0.111	0.161	0.211	0.312	0.412	0.512	0.613	0.814	1.015	1.517	2.019	2.521			
67	0.030	0.060	0.110	0.160	0.210	0.308	0.409	0.508	0.608	0.808	1.007	1.505	2.004	2.502	67		
	0.030	0.060	0.109	0.159	0.208	0.307	0.406	0.505	0.604	0.802	1.000	1.494	1.989	2.484			
68	0.030	0.059	0.108	0.158	0.207	0.305	0.403	0.501	0.600	0.796	0.992	1.484	1.975	2.466	68		
	0.030	0.059	0.108	0.158	0.205	0.303	0.400	0.498	0.595	0.790	0.985	1.473	1.960	2.448			
69	0.030	0.059	0.107	0.155	0.204	0.301	0.397	0.494	0.591	0.785	0.978	1.462	1.946	2.430	69		
	0.029	0.058	0.106	0.154	0.202	0.299	0.395	0.491	0.587	0.779	0.971	1.452	1.932	2.413			
70	0.029	0.058	0.106	0.153	0.201	0.296	0.392	0.487	0.583	0.774	0.964	1.441	1.918	2.396	70		
REV =>		2	5	10	15	20	30	40	50	60	80	100	150	200	250	<= REV	
Type of meter		PRICE 822 AA														Condition at rating	
Owner		ALBERTA ENERGY AND NATURAL RESOURCES														REPAIRED	
																Suspension	
																ROD	

Fig. 4. CURRENT METER RATING TABLE.

6.3 Streamflow Measurement Under Ice by the Velocity-Area Technique

Ice Safety. Review Section 2 of this manual concerning special precautions which must be taken when working on ice-covered streams.

The procedures for making streamflow measurements of ice-covered streams are essentially the same as those described in Section 6.2, but certain additional work and measurements are required.

The observer should ensure the following conditions exist (U.S. Department of the Interior, 1977):

1. The flow is well distributed in the cross-section of the stream.
2. No slush ice is affecting the flow.
3. No part of the cross-section is blocked by frazil or slush ice.
4. The current meter is free to rotate.
5. The meter is not affected by vertical pulsations of water in the holes bored in the ice.

6. The meter is not affected by icing caused by intermittent exposure to cold air.

Once the tape measure is stretched from the initial point across the stream at right angles to the direction of current flow and securely fastened to the opposite bank, holes must be made in the ice to allow the current meter to be lowered down into the water.

1. Use the ice auger to make a hole through the ice large enough to allow the current meter to be lowered through the ice.

2. Use the sieve to remove the broken pieces of ice from the hole to prevent them from being caught up or jammed in the current meter, or from causing an impediment to the water flow downstream from the sampling site. If an impediment in flow is observed, a new location must be found downstream from the original site.

3. Measure the total depth of the water and ice through the hole made in the ice. Record this on the HYDROMETRIC SURVEY NOTES (Figure 3).

4. Measure the distance from the surface of the water in the hole to the bottom of the ice. Subtract this from the total depth of the water and ice to obtain the actual water depth under the ice and record this on the HYDROMETRIC SURVEY NOTES.

5. Use the depth of water under ice for a reference to set the CURRENT METER to the proper depth marking on the WADING ROD and take the current measurement as described in Section 6.4 of this volume.

The water may rise up in the hole in the ice due to hydrostatic pressure exerted by the weight of the ice and of people on the ice, in addition to restriction on the streamflow caused by the downstream ice cover. It is therefore not really a part of the streamflow to be measured. Under such conditions a new location must be found upstream of the original site.

7. ANALYSIS AND REPORTING

No scientific work is completed until the data collected have been analysed and properly reported. This should be done as soon as the crew returns from the field to headquarters and the equipment has been properly unloaded and is drying.

7.1 Calculation of Total Stream Discharge

To analyse the data collected using the current meter readings on the cross-sectional transect of the stream, the HYDROMETRIC SURVEY NOTES (Figure 3) and the appropriate Current Meter Rating Table (Figure 4) for the current meter used are required.

NOTE: Each individual meter has its own velocity rating curve and thus its own Current Meter Rating Table. It is good practice to have the current meter checked annually. This can be done free of charge (to the Province) through the Inland Waters Laboratory of Environment Canada in Burlington, Ontario.

In most cases the velocities may be read directly from the Current Meter Rating Table by reading across the top of the table to the correct number of revolutions, and then down the column to the elapsed time (read to the nearest half second).

In this example (Figure 4) the formula is:

$$\text{velocity in m/s} = .6679 \times \text{rev/s} + 0.0102$$

7.2 Calculations Using HYDROMETRIC SURVEY NOTES

Letters are placed in the appropriate columns of Figure 5 at the bottom of the sheet for use in the following examples of calculations. The top portion of the sheet contains worked out examples of the calculations in the proper columns.

1. Calculation of WIDTH of subsection sampled:

$$\frac{(B - A)}{2} + \frac{(C - B)}{2} = G, \quad \frac{(C - B)}{2} + \frac{(D - C)}{2} = H, \text{ ect.}$$

2. The DEPTH OF WATER (K,L,M,N) is obtained by direct measurement and recorded in the field.

3. The REVOLUTIONS (O,P,Q,R) are obtained from the current meter and are recorded in the field.

4. The TIMES (S,T,U,V) are obtained from the stop watch and are recorded in the field.

5. The mean VELOCITY (W,X,Y,Z) for each subsection is obtained by reading from the Current Meter Rating Table

HYDROMETRIC SURVEY NOTES

Station UPPER BEALICK Sta. No. 37
 Date May 13 1988 Party WJL
 Width Area Mean vel. CORR. M.G.H.
 Temp. A °C W DISCHARGE .0841
 Measurement began at 1141 ended at 1210

Livels obtained 1.6 Meter No. ENR-16

Time	Gauge Readings (m.)			
	Station	Pen	Inside	Outside
1141			4.17L	
Weighted M.G.R.				
Correction				
Correct M.G.H.				

kg weight.

Date rated

Meter

above

Method

Coast.

No. of vert. sect.

Angle of flow

Obs. seen

Book insp.

days remaining

Wind Ca/m

Supply rd

Weather conditions Cloudy

MEASUREMENT: (Wading) cableway, boat, ice cover, upstream, downstream side of

bridge m, km (above/below gauge)

REMARKS: Include condition of station equipment:

Water Temperature - 3°C.

Checked by

Computed by

Form FLU 502/82

STATION	Distance from initial point	Width	Total depth W.S. to bottom	Depth under ice	Reck. lons	VELOCITY		Area	Discharge
						At point	Mean		
0.9	0.9	0.15	0.08		7	44.5	.115	.014	.0014
1.0	1.0	.30	.11		10	40	.177	.022	.0029
1.2	1.2	.30	.10		15	44.5	.235	.020	.0047
1.4	1.4	.30	.08		20	41	.336	.016	.0054
1.6	1.6	.30	.08		10	48.5	.148	.016	.0024
1.8	1.8	.30	.08		30	40	.344	.016	.0085
2.0	2.0	.30	.08		30	47	.437	.016	.0070
2.2	2.2	.30	.08		30	52	.396	.016	.0068
2.4	2.4	.30	.10		20	42	.328	.020	.0066
2.6	2.6	.30	.11		10	45	.159	.022	.0035
2.8	2.8	.30	.12		40	54	.505	.024	.0131
3.0	3.0	.30	.16		30	51	.372	.032	.0087
3.2	3.2	.30	.16		30	52	.396	.032	.0126
3.4	3.4	.30	.17		5	40	.094	.034	.0032
3.6	3.6	.30	.17		2	40	.044	.034	.0011
3.8	3.8	.30	.17						
3.9	3.9	.30	.17						
A	A	.30	.17						
B	B	.30	.17						
C	C	.30	.17						
D	D	.30	.17						
E	E	.30	.17						
F	F	.30	.17						

Fig. 5. COMPLETED EXAMPLE OF HYDROMETRIC SURVEY NOTES.

(Figure 4), or by using the formula given at the top right-hand part of the table for calculating Velocity in Metres per Second.

6. The AREA is obtained by multiplying the Width (G,H,I,J) of the subsection by the DEPTH OF WATER (K,L,M,N) for that subsection, e.g.

$$a = G \times K, b = H \times L, \text{ etc.}$$

7. The DISCHARGE for each subsection is determined by multiplying the MEAN VELOCITY by the AREA, e.g.

$$e = W \times a, f = X \times b, \text{ etc.}$$

8. The TOTAL DISCHARGE for the stream at the cross-sectional transect during the period when the streamflow measurements were taken is the Sum of the Subsection Discharges, e.g.

$$i = e + f + g + h.$$

7.3 Calculation of Total Discharge by Computer Program

The calculation of total stream discharge may be done with the aid of a computer program (file name HSNRP2 or file name QCALC). The instructions are given below. Wherever "return" is under the "You Type" column it indicates the use of the enter or return key, which may have a bent arrow pointing to the left on some keyboards rather than a word identification.

Insert a floppy disk containing DOS, BASICA and the file HSNRP2 into the computer.

<u>The Computer Will Prompt</u>	<u>You Type</u>
A<	BASICA return
OK	F3-key return
LOAD	HSNRP2 return
OK	F2-key return
Enter the Current Meter....	.0102,.6679 return (e.g. for ENR-16 only)
Station Name	The Station Name return
Date and Time of Measurement	Day Month Year,Time (e.g. 19 July 1986,1500)
Enter Initial Point,Depth...	0.9,0,0,0 return (e.g. where the edge is 0.9)
Are these values correct	Y or N return

Enter Distance from Initial	Distance from Initial Point,
Point....	Depth, Revolutions, Time return
.	(e.g.1.0,.08,7,44)
(Continue to end of data)	.
Enter Distance from	3.9,0,0,0 return
	(e.g. 3.9 is the opposite edge
	of the stream)
Are these values correct	Y
Distance from Initial....	9999 , 0 , 0 , 0 return
	(this will end the program).

An example of the printout of calculations is shown in Figure 6. Instructions for using the program QCALC with Lotus 1-2-3 software are provided in figure 7.

7.4 Reporting

Once the data on the HYDROMETRIC SURVEY NOTES have been calculated and the field descriptive notes have been compiled, copies of the complete report should be forwarded as directed to interested parties.

DISCHARGE CALCULATION AT upper deerlick

DATE:13 MAY 1985

TIME:1141

DISTANC	WIDTH	DEPTH	REVOLU	TIME	VELOCI	AREA	DISCHA
0.900	0.000	0.000	0.000	0.000	0.000	0.000	0.0000
1.000	0.150	0.080	7.000	44.500	0.115	0.012	0.0014
1.200	0.200	0.110	10.000	40.000	0.177	0.022	0.0039
1.400	0.200	0.100	15.000	44.500	0.235	0.020	0.0047
1.600	0.200	0.080	20.000	41.000	0.336	0.016	0.0054
1.800	0.200	0.080	10.000	48.500	0.148	0.016	0.0024
2.000	0.200	0.080	20.000	40.000	0.344	0.016	0.0055
2.200	0.200	0.080	30.000	47.000	0.437	0.016	0.0070
2.400	0.200	0.080	30.000	52.000	0.396	0.016	0.0063
2.600	0.200	0.100	20.000	42.000	0.328	0.020	0.0066
2.800	0.200	0.110	10.000	45.000	0.159	0.022	0.0035
3.000	0.200	0.120	40.000	54.000	0.505	0.024	0.0121
3.200	0.200	0.160	20.000	51.000	0.272	0.032	0.0087
3.400	0.200	0.160	30.000	52.000	0.396	0.032	0.0127
3.600	0.200	0.170	5.000	40.000	0.094	0.034	0.0032
3.800	0.150	0.120	2.000	40.000	0.044	0.018	0.0008
3.900	0.050	0.000	0.000	0.000	0.000	0.000	0.0000

AVERAGE DISCHARGE= 0.0841
 ACCURACY: 0.119

Fig. 8. COMPUTER PRINTOUT OF STREAMFLOW DATA USING HSNRP2.

A1: QCALC

	A	B	C	D	E	F	G	H
1. QCALC	Calculation of Streamflow							
2.								
3. Instructions	1. enter distance in column A							
4.	2. enter depths in column C							
5.	3. enter revolutions in column D							
6.	4. enter time in column E							
7.	5. enter current velocity formula in first velocity							
8.	cell and copy down column							
9.	eg. $0.6754 * D20/E20 + 0.0063$							
10.	6. there is room for about 20 measurements							
11.	7. calculations are done as values are entered.							
12.	8. see below for rest of instructions							
13. FOREST	CREEK			DATE			TIME	
14.								
15.	-----							
16.	distance	width	depth	revs	time	velocity	area	Q
17.	meters	meters	meters		sec	m/2	m	m
18.	-----							
19.	1.0	edge						
20. For cell B20								
21.	Type: $(A20-A19) / 2 + (A21-A20) / 2$							
22.	/ W C							
23.	this will copy the formula for calculations width							
24. For cell F20								
25.	Type: $0.6754 * D20/E20 + 0.0063$							
26.	/ W C							
27.	this will copy the formula for calculating velocity							
28. For cell G20								
29.	Type: $B20 * C20$							
30.	/ W C							
31.	this will copy the formula for calculating area							
31. For cell H20								
32.	Type: $F20 * G20$							
33.	/ W C							
34.	this will copy the formula for calculating discharge							
35. For cell H36								
36.	Type: @ sum (H20..H35)							
37.	this will calculate the total discharge							

Fig. 7. COMPUTER PRINTOUT OF STREAMFLOW DATA USING QCALC.

QCALC

CALCULATION OF STREAMFLOW

INSTRUCTIONS:

1. ENTER DISTANCES IN COL A
2. ENTER DEPTHS IN COL C
3. ENTER REVOLUTIONS IN COL D
4. ENTER TIMES IN COL E
5. ENTER CURRENT METER VELOCITY FORMULA IN FIRST
VELOCITY CELL & COPY DOWN COL
EG. $0.6754 * D17/E17 + 0.0063$
6. THERE IS ROOM FOR ABOUT 20 MEASUREMENTS
7. CALCULATIONS ARE DONE AS VALUES ARE ENTERED.
8. METER # ENR

FOREST:

CREEK:

DATE:

TIME:

DISTANCE meters	WIDTH meters	DEPTH meters	REVS	TIME sec	VELOCITY m/s	AREA m ²	Q m ³ /s
1.00	EDGE	NA					
1.10	0.100	0.10	5	45.0	0.0813	0.0100	0.0008
1.20	0.125	0.10	5	45.0	0.0813	0.0125	0.0010
1.35	0.125	0.12	10	43.0	0.1634	0.0150	0.0025
1.45	0.125	0.12	10	42.0	0.1671	0.0150	0.0025
1.60	0.125	0.12	10	48.0	0.1470	0.0150	0.0022
1.70	0.100	0.13	15	47.0	0.2219	0.0130	0.0029
1.80	0.125	0.14	15	54.0	0.1939	0.0175	0.0034
1.95	0.150	0.14	15	55.0	0.1905	0.0210	0.0040
2.10	0.175	0.14	20	55.0	0.2519	0.0245	0.0062
2.30	0.200	0.15	20	53.0	0.2612	0.0300	0.0078
2.50	0.200	0.15	20	52.0	0.2661	0.0300	0.0080
2.70	0.175	0.15	15	45.0	0.2314	0.0263	0.0061
2.85	0.150	0.16	15	45.0	0.2314	0.0240	0.0056
3.00	0.125	0.13	10	42.0	0.1671	0.0163	0.0027
3.10	0.100	0.12	10	47.0	0.1500	0.0120	0.0018
3.20	EDGE	NA					0.0574

Fig. 7a USING QCALC.

8. CLEANUP AND STORAGE

As soon as the equipment is brought back from the field it must be carefully dried and cleaned to prevent corrosion during storage.

Check all equipment for wear or damage, especially the current meter, wading rod and tape measure. If repairs are required make sure they are done immediately so the equipment will be ready to use the next time it is needed.

Check the current meter as described in Section 5.1 before storage. Occasionally remove the CONTACT CHAMBER CAP and lubricate all moving gears with silicone oil or RISLONE oil. Tighten the CONTACT CHAMBER CAP after lubrication.

Disconnect the battery from the equipment to prevent corrosion. Recharge the battery if it is rechargeable. Check the charge of the battery to ensure it is not discharged before placing it in storage.

Replace supplies such as forms and any other materials that will be needed for the next streamflow measurement.

Carefully pack and store all equipment and supplies in

clean, dry conditions. It is good practice to go through the equipment list (Section 4) as the equipment is placed in storage to make sure that nothing will be found missing or broken the next time it is necessary to prepare for field work. Should a hydrologic event occur which must be measured on short notice there will not be time to repair or replace equipment and supplies.

9. STAGE-DISCHARGE RELATIONSHIPS

9.1 Introduction

A stream stage-discharge measurement program is normally carried out to establish a relationship between the stage and the discharge for a full range of stage and discharge conditions. The relationship is plotted to establish a smooth stage-discharge rating curve.

9.2 Definition of Stage

The stage is the elevation of the water surface in a stream as measured by a river gauge with reference to some arbitrarily selected zero datum. The datum is the elevation of the zero point of the reference gauge. In normal practice an arbitrary datum below the elevation of possible zero flow is selected. This prevents stage values from becoming negative in low flow conditions (U.S. Department of the Interior, 1977).

9.3 Factors Affecting Natural Stage-Discharge Relationships

To ensure stability of the stage-discharge relationship, the location of the site should conform to the following criteria.

1. The streambed and streambank should be stable. Changes

in the channel cross-sectional profile that occur at flood flows will be reflected in the stage-discharge rating curve.

2. The stream reach must be free from significant sediment storage.

3. The reach must be free from variable backwater .

4. The reach should be located to avoid backwater effect, such as beaver activity.

5. The reach should not contain bends in the channel near the gauge (U.S Department of the Interior, 1977).

9.4 Methods of Measuring the Stage

Two methods are available for measuring the stage; manual observation, and automatic continuous recording devices.

Manual Observation. These can be done using the staff gauge (Figure 8). This consists of a graduated scale attached to a vertical stake fixed in the stream. Observations are made by direct reading of the water level (to the nearest millimetre) on the staff gauge.

Another method uses a crest gauge (Figure 9). The crest gauge records the maximum stage which has occurred during the time interval since the gauge was prepared and the reading is taken. The gauge consists of a two metre piece of ANGLE IRON, two 8.5 cm diameter RING CLAMPS, a 1.5 m length of PVC PIPE with an inside diameter of 7.5 cm, a STRIP of clear PLEXIGLASS 1.5 m long by 3 cm wide and a fitted PLASTIC CAP for the PVC pipe.

The PVC PIPE must have five 0.5 mm holes drilled through the PIPE at two centimetre intervals from the bottom of the PIPE.

Attach the PVC PIPE firmly to the ANGLE IRON with the RING CLAMPS so that it is perpendicular to the stream bed with the perforated end on the bottom. Mark a line of dye or ink

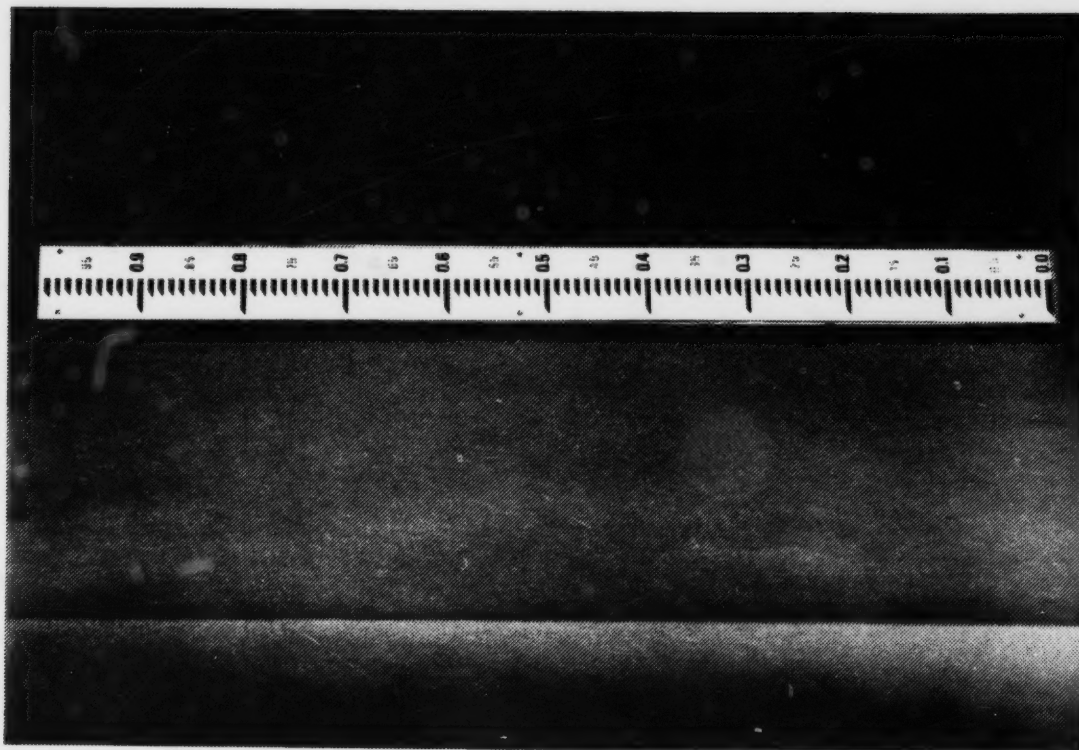


Fig. 8. STAFF GAUGE.

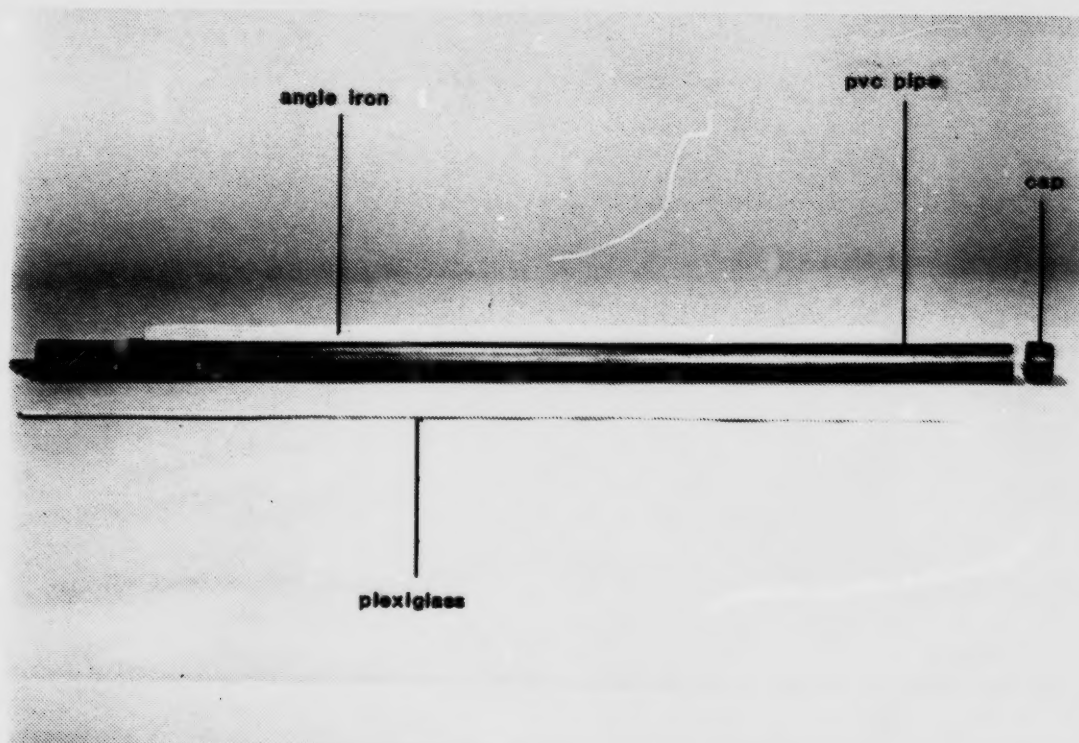


Fig. 9. CREST GAUGE.

along the total length of the PLEXIGLASS STRIP using an eye dropper or pipette.

Insert the PLEXIGLASS STRIP inside the PVC PIPE and cap the top end of the PIPE firmly with the plastic CAP.

As the water level rises the dye washes off the PLEXIGLASS STRIP, leaving a record of the maximum height of the water level in the PIPE during the observation period.

To read the gauge, measure the length of the PLEXIGLASS STRIP where the dye has washed off with a tape measure. Record this measurement as the Maximum Stage on the HYDROMETRIC SURVEY NOTES (Figure 3).

Automatic Continuous Recorders.

The Stevens Type A Model 71 Water Level Recorder is a float-operated recorder that provides a permanent, continuous long-term graphic record of stage levels. A mechanical clock controls the rate of strip chart movement. The rise and fall of the float moves a marking pen laterally on the chart, reversing automatically when it reaches the end of the chart. In this way all heights of the stream can be recorded.

These charts are digitized annually to obtain hourly and mean daily streamflow for the period of record.

Installation of a gauging station and operation of a water level recorder are discussed in the following:

1. The INSTRUMENT SHELTER (Figure 10) is mounted above the STILLING WELL and serves two functions. It provides a waterproof enclosure to prevent moisture and dust from entering the WATER LEVEL RECORDER, and it provides a platform on which the WATER LEVEL RECORDER is mounted. The shelter should be locked to prevent tampering by unauthorized persons.

2. The functions of the STILLING WELL are to protect the float system, to provide within the well an accurate reproduction of the water level in the channel and to dampen

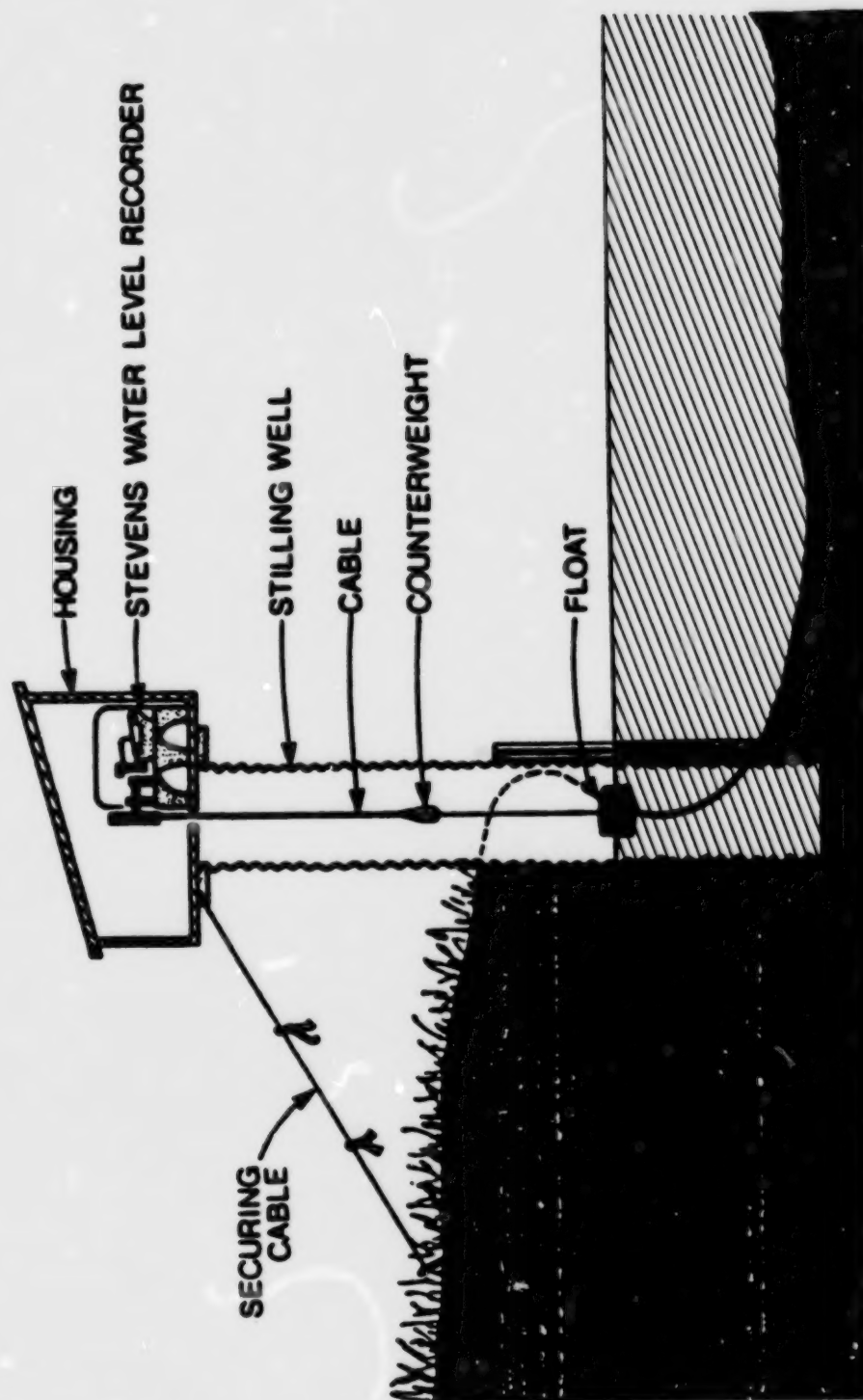


Fig. 10. COMPONENTS OF A STREAM GAUGING STATION.

oscillations of the water surface in the stream. The guidelines discussed in this section for the installation of stilling wells were developed by the International Organization for Standardization (1981) and should always be followed to get acceptable results.

A. The well may be placed in the bank of a channel but should not be located directly in the channel where flow conditions would lead to separation and stagnation effects.

B. The well should not interfere with the flow pattern in the approach channel.

C. The well must be vertical and firmly anchored to the bank so it remains stable at all times.

D. The well must have sufficient height and depth to allow the float to travel freely the full range of water levels.

E. The location of the well should be sensitive enough to detect significant changes in stage when accompanied by significant changes in discharge.

3. The installation of a STILLING WELL (See Figure 11) is discussed in five parts.

A. The STILLING WELL is composed of a culvert approximately 60 cm diameter and 2 to 2.5 m long, with a shelter box mounted on the top.

B. Using a shovel, dig a shallow 20 to 30 cm depression into the bank and down 20 to 30 cm into the substrate.

C. Firmly attach the STILLING WELL to the side of the bank with GUIDE CABLES. Pull the cables around steel ANCHOR RODS and tighten the cables using U-CLAMPS.

D. Place BOULDERS around the bottom of the STILLING WELL to dampen oscillations in stage levels and to stabilize the culvert to the streambank.

E. Make a mark on the culvert as a height reference. Use a surveying level to relate this mark to another, such as a nail driven in a tree. Movement of the STILLING WELL may occur from scouring or frost action, so new level marks on the culvert should be established at least once a year as soon as the frost thaws from the stream substrate.

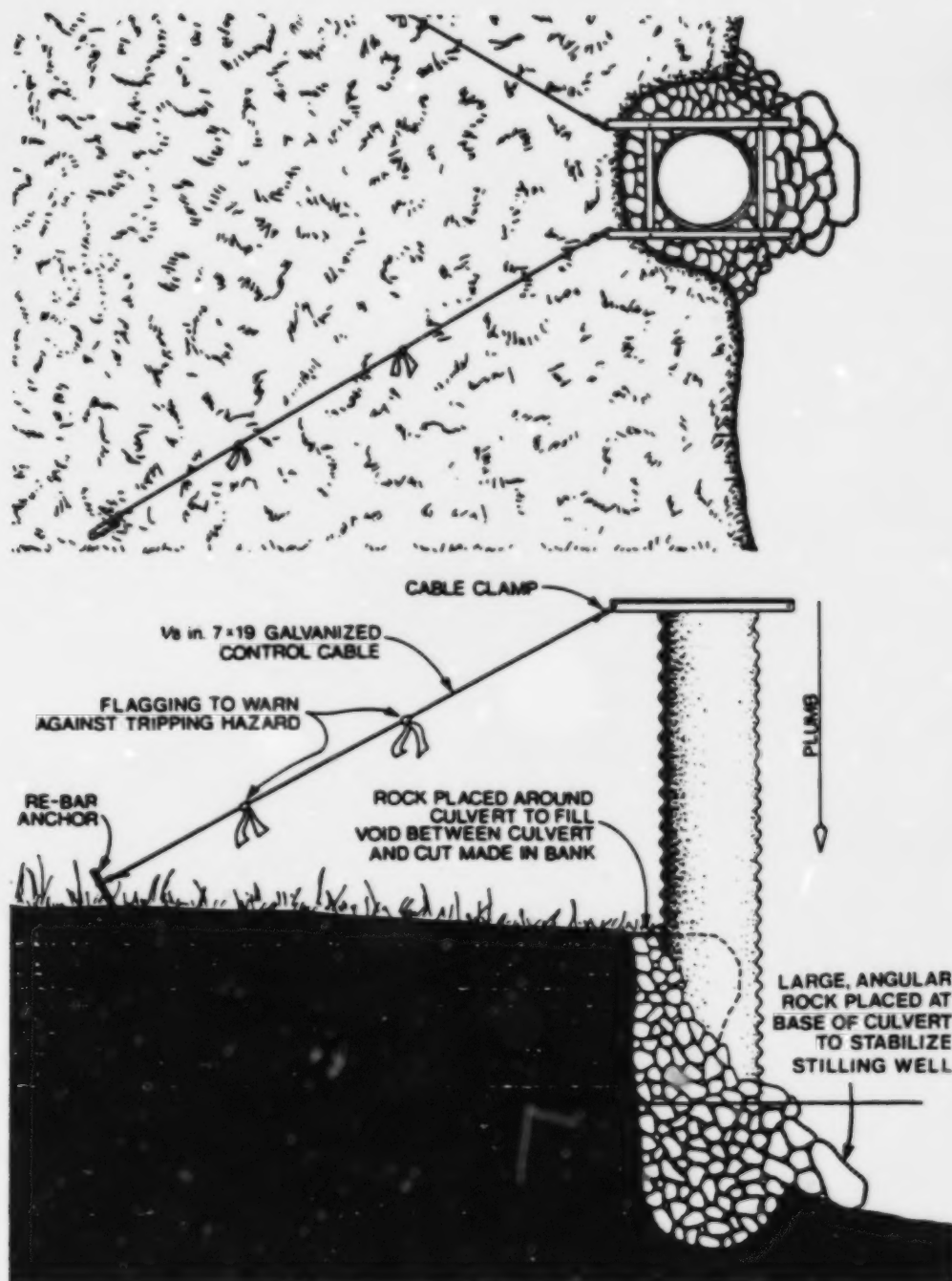


Fig. 11. STILLING WELL INSTALLATION.

Major storms can cause considerable scouring so re-levelling is required following a storm to determine whether the culvert has been moved.

4. There are three steps to the installation of the WATER LEVEL RECORDER in the INSTRUMENT SHELTER.

A. Place the WATER LEVEL RECORDER (Figure 10) on the floor of the INSTRUMENT SHELTER.

B. Adjust the LEGS on the WATER LEVEL RECORDER to level the instrument.

C. Place and tighten SCREWS on the legs to secure the RECORDER to the platform of the INSTRUMENT SHELTER.

4. Once the WATER LEVEL RECORDER is secured in the INSTRUMENT SHELTER the next step is to assemble the rest of the equipment needed to operate the system. These instructions are adapted from the original Stevens water level recorder operating manual.

A. To mount the FLOAT PULLEY on the RECORDER (Figure 12), first mount the SLIGHTLY CURVED CLAMP WASHER with the cupped side toward the FLOAT PULLEY. Then mount and tighten the PULLEY CLAMP ASSEMBLY against the

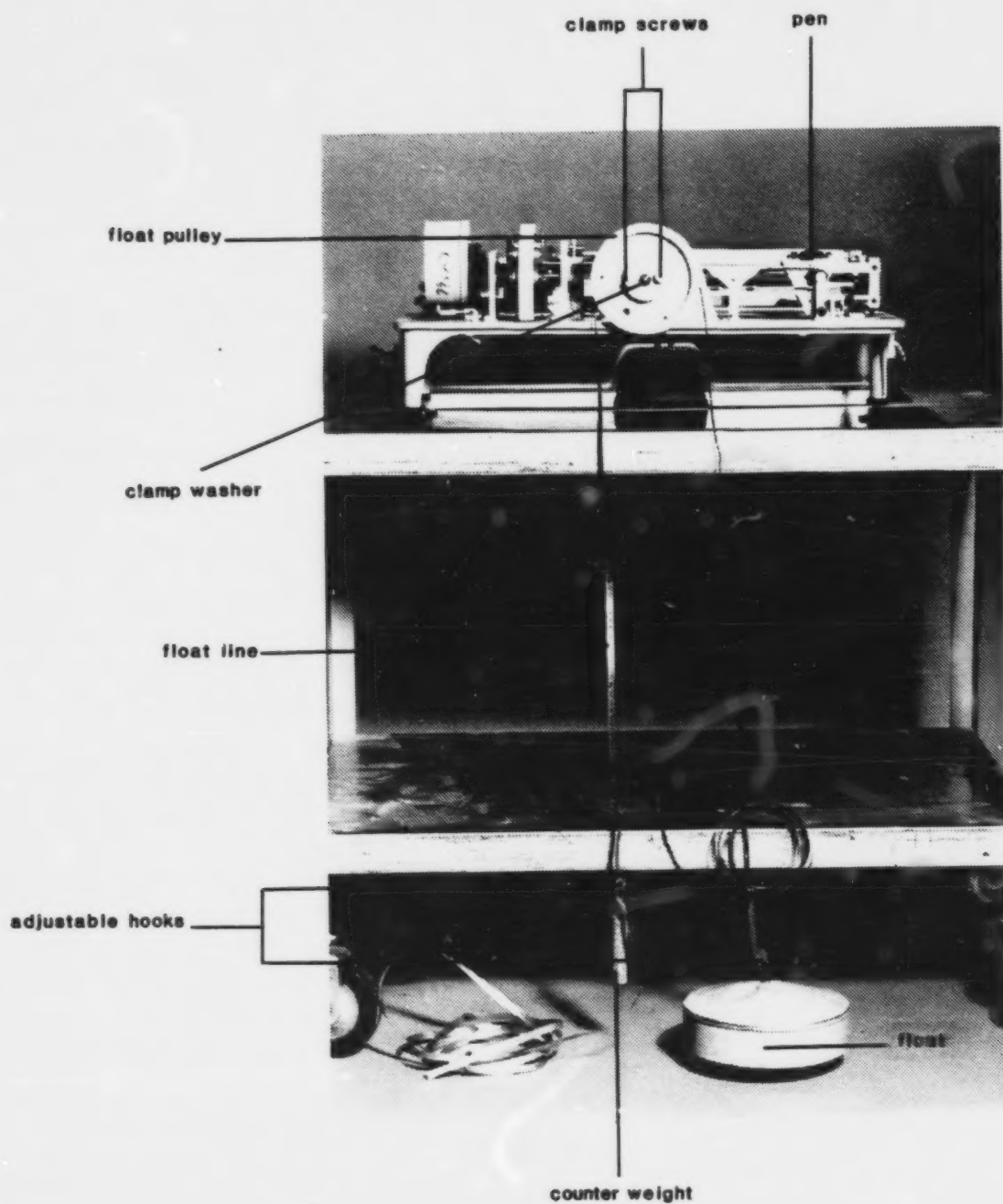


Fig. 12. WATER LEVEL RECORDER ASSEMBLY.

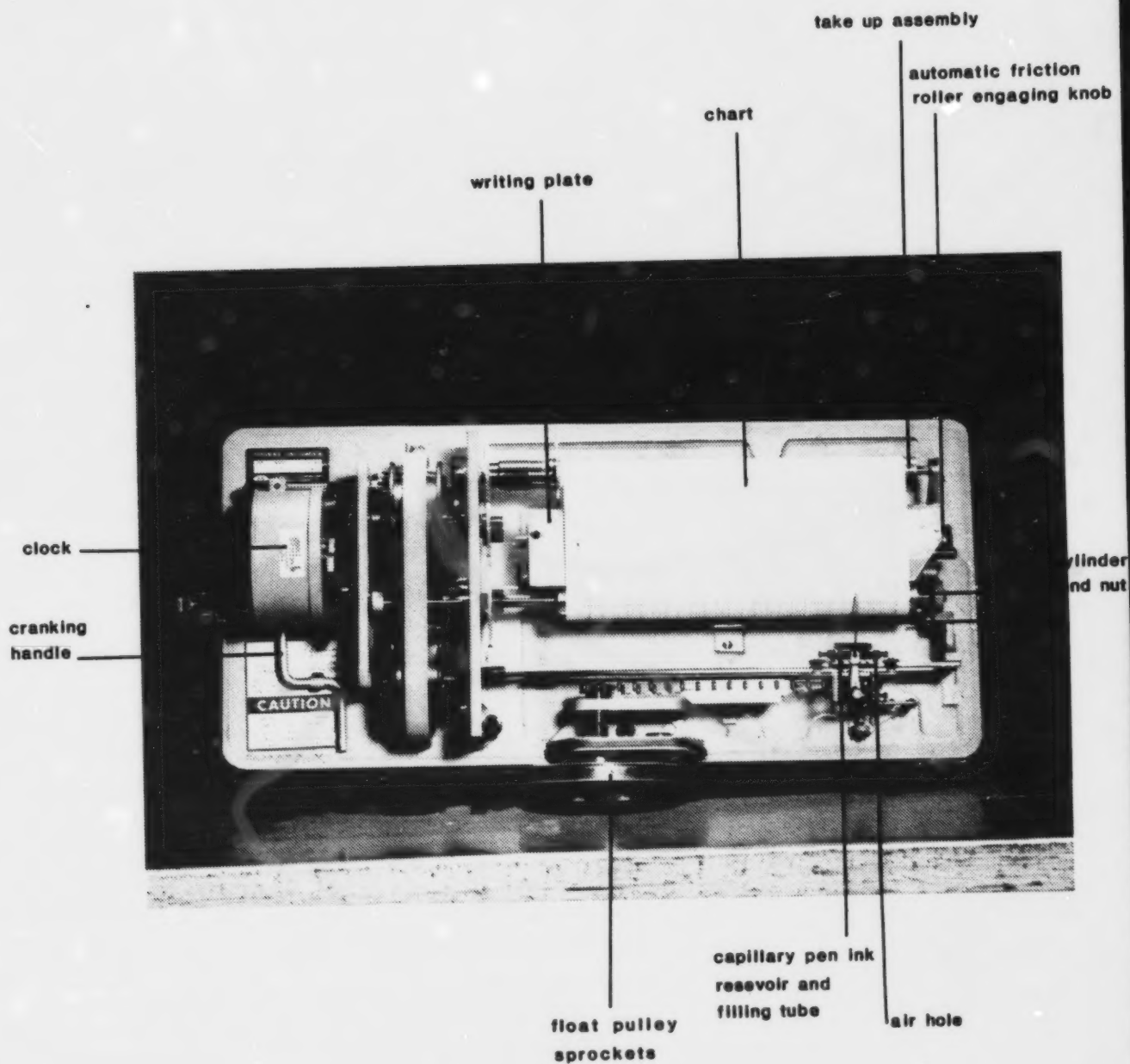


Fig. 13. EXPLODED VIEW OF RECORDER.

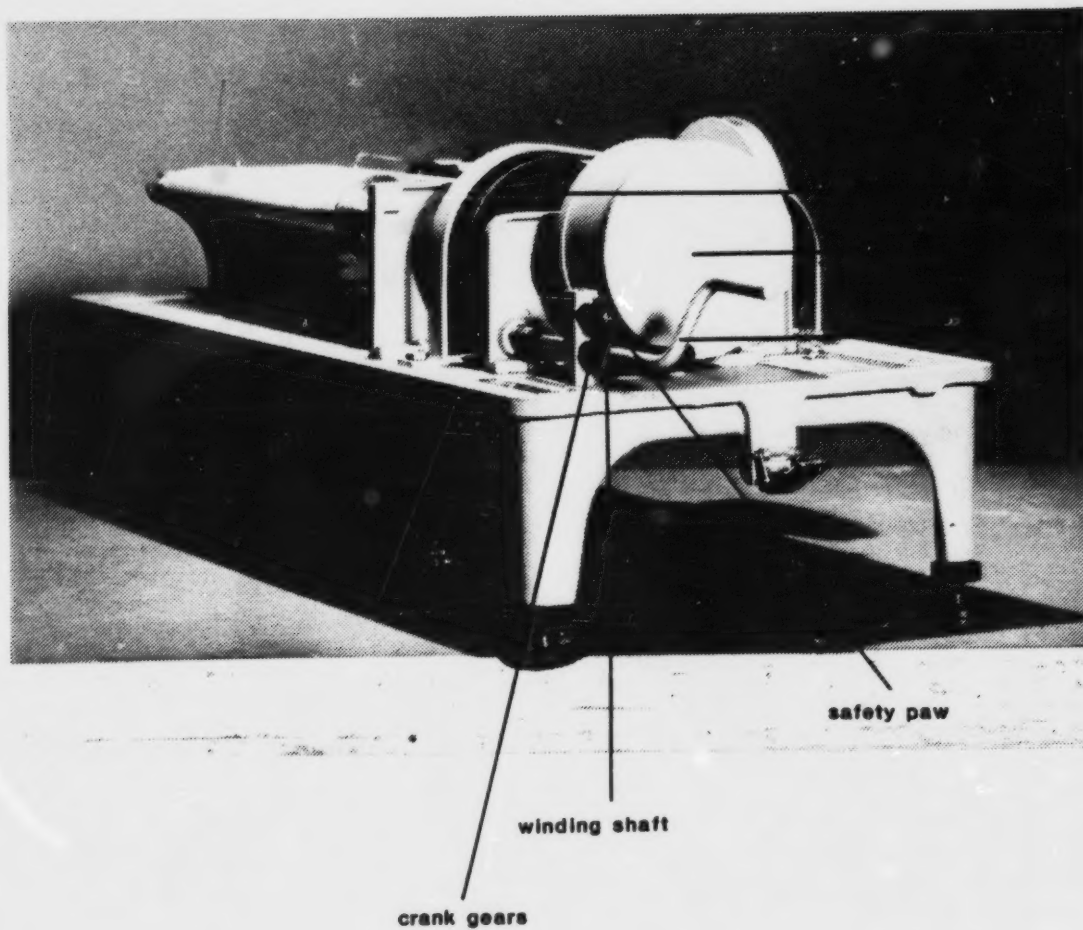


Fig. 13a. EXPLODED SIDE VIEW OF RECORDER.

CLAMP WASHER. Lightly tighten the NUT against the CLAMP ASSEMBLY. Finally, tighten the CLAMP SCREWS. Note that one has right-hand threads and the other has left-hand threads.

B. To mount the FLOAT LINE (Figure 12) note that there are two ADJUSTABLE HOOKS provided for attaching the FLOAT LINE to the FLOAT and to the COUNTERWEIGHT. The FLOAT LINE should be long enough that the COUNTERWEIGHT will not run into the base of the INSTRUMENT SHELTER when the FLOAT is at its lowest stage nor will the top of the FLOAT strike the base of the INSTRUMENT SHELTER when the FLOAT is at its highest stage. The FLOAT and COUNTERWEIGHT must pass each other freely and should not touch the side of the STILLING WELL.

Attach the FLOAT LINE to the FLOAT and lower it to the surface of the water. Pass the FLOAT LINE over the PULLEY, making sure that the TAPE PERFORATIONS fit their respective SPROCKETS on the PULLEY. Attach the COUNTERWEIGHT and lower it into position. Check and ensure that the FLOAT and COUNTERWEIGHT operate through the entire operating range without interference. Any additional excess TAPE should be tied off.

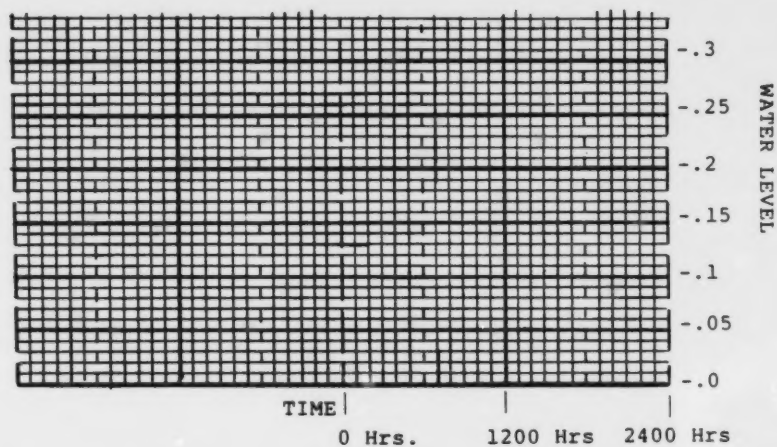
C. To position the PEN, turn the FLOAT PULLEY to raise

the FLOAT a short distance. Check that the PEN moves to the right. If it does not, disengage the FLOAT TAPE from the FLOAT PULLEY and loosen the CLAMP SCREWS. Move the PEN until it indicates the correct stage. Refer to Figure 14 to determine and then set the correct stage on the CHART. While holding the PEN in this position, tighten the CLAMP SCREWS (Figure 12) evenly to secure the FLOAT PULLEY. Remember that one CLAMP SCREW has right-hand threads and the other has left-hand threads. Lift up the FLOAT TAPE again to check and ensure that the PEN moves to the right when the stream depth increases.

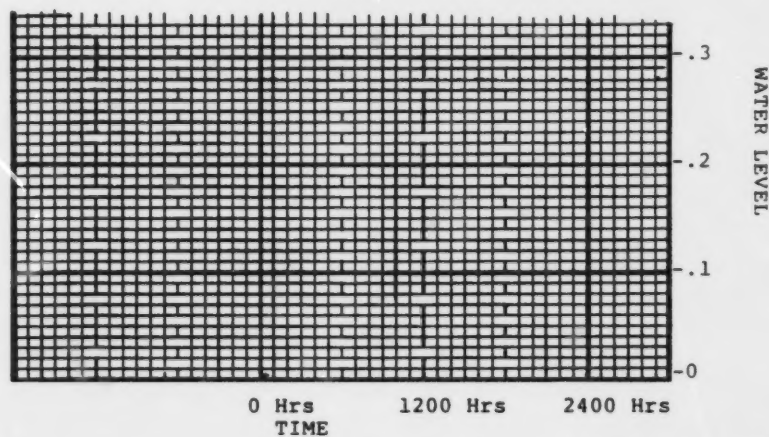
D. To start the CLOCK (figure 12) screw the CRANK HANDLE counterclockwise (it has left hand threads) into the end of the WINDING SHAFT. Push the WINDING SHAFT in until the CRANK GEARS engage. Wind the CLOCK until the "STOP" sticker appears on the SPRING. When winding the CLOCK the SAFETY PAW to the left of the CLOCK moves up and down. Stop winding when the PAW is released, at which time the WINDING SHAFT GEAR should spring out of engagement.

E. To regulate the CLOCK, first screw the CRANK HANDLE into position and wind until the SAFETY PAW to the left of the CLOCK DROPS into the DOWN position. Then unscrew the CLOCK COVER to expose the TIME REGULATING

Stevens Level Recorder Charts



To read charts, vertical spacings indicate .01 m. Rise or Fall in water level and horizontal spacings indicate 1 Hour Time Intervals.



To read chart, vertical spacings also indicate .01 m Rise or Fall in water level. Time interval spacing is the same as above.

Fig. 14. STEVENS LEVEL RECORDER CHART.

KNURLED NUT. There are two clock models in use, and their regulating adjustments turn in opposite directions. Note the "F" and "S" markings. Rotating the KNURLED NUT one quarter turn toward the "S" will slow the CLOCK approximately 30 seconds each day.

F. To install the CHART, first remove the WRITING PLATE between the CHART DRIVE and the TAKE-UP CYLINDER (Figure 13) Remove the SUPPLY CYLINDER from the RECORDER and take the large KNURLED CIRCULAR WASHER out of the end. Remove the old CHART CORE. Observe that the CORE of the new CHART ROLL is flushed with the CORE at one end and protrudes from the other. Slip the new CHART ROLL onto the SUPPLY CYLINDER with the flush end towards the FLANGE and tighten the KNURLED WASHER NUT firmly. Place the SUPPLY CYLINDER in its BEARINGS with the FLANGE to the left. Check that the AUTOMATIC ROLLER ENGAGING KNOB at the right end of the RECORDER is holding the FRICTION ROLLER in the raised position.

Crease the PAPER about 2 cm from the end. Thread the creased edge up between the CHART DRIVE CYLINDER and the FRICTION ROLLERS. Replace the WRITING PLATE and pull the chart up around and over the DRIVE CYLINDER and WRITING PLATE.

Pull the CHART until it is about 3 cm beyond the TAKE-UP CYLINDER, with the left edge against and square with the CYLINDER FLANGE. Install the CHART CLAMP. To adjust the PAPER on the TAKE-UP CYLINDER so that it will run true, hold the CHART SUPPLY CYLINDER SHAFT and rotate the KNURLED FLANGE of the TAKE-UP CYLINDER away from you. Allow the CHART PAPER to slip between the TAKE-UP CYLINDER and the CHART CLAMP to a maximum of three of the smallest divisions. Then, while keeping the PAPER taut by lightly restraining the SUPPLY CYLINDER SHAFT, rotate the TAKE-UP CYLINDER until it has at least one full turn of CHART PAPER on the CYLINDER. Push the AUTOMATIC FRICTION ROLLER ENGAGING KNOB to the left to return the FRICTION ROLLERS to their drive position.

G. To prepare the STYLUS, the CAPILLARY-PEN INK RESERVOIR should be filled to within two millimetres of the top of the BARREL. To prime the STYLUS, close the AIR HOLE with one finger and with a second finger press repeatedly on the FILLING TUBE to create a pumping action. Continue until ink appears on the CHART.

H. Use only water to clean the RESERVOIR, PEN and CAPILLARY TUBE. Water can usually be forced through the TUBE in the same manner as in priming the PEN with ink. However, if the CAPILLARY TUBE is completely

plugged with dried ink, use the PEN CLEANING WIRES furnished with each recorder.

I. The operating time of a fully wound RECORDER is about four and one-half months minimum. The clocks are usually accurate enough for most needs. Small errors may be compensated for during the digitizing process. Large errors in timing would require clock servicing. If adjustments are made they should be done during low flow or non-storm periods. If the chart is moving too fast the chart should be moved back to the correct time. If the chart is moving too slowly it should be moved forward to the correct time.

J. The stainless steel FLOAT TAPES are perforated to match the FLOAT PULLEY SPROCKETS. A MOUNTING BRACKET on the base of the INSTRUMENT SHELTER indicates the correct water level. The stage level together with the date, time of measurement and the observer must be marked on the chart. A marker should be placed on the chart to indicate that the stage level has been measured. This is done by rotating the float pulley slightly to the left and then slightly to the right. The float pulley will then automatically move back to its original point of reference.

K. Parts and supplies may be ordered directly from the factory. Figure 12 includes a parts list. Be sure to include the recorder serial number with all orders for parts.

9.5 Stream Flow Information Agencies

Stream flow data are also collected in Alberta by Environment Canada's Water Survey of Canada, headquartered in Calgary, and by Alberta Environment's Technical Services Division of Edmonton. Both agencies are primarily concerned with major river systems and lakes, with only minor involvement in small streams. On the other hand, Alberta Forest Service Watershed Management works on small wadable Green Area streams in an attempt to determine changes in flow regime due to various land uses, primarily timber harvesting.

GENERAL REFERENCES

American Public Health Association, American Water Wastes Association, and Water Pollution Control Federation, 1980. Standard Methods for the Examination of Water and Wastewater. 15th edition. American Public Health Association, New York. 874p.

Gray, D. M. and Male, D. H. Editors. 1981. Handbook of Snow: Principles, Processes, Management and Use. Pergamon Press.

Herschy, R., 1970 The Magnitude of Errors at Flow Measurement Stations. Vol. 1. Proceedings, Symposium on Hydrometry, Koblenz. Sept. 1970. pp. 109- 131. IAHS Paris Publication No. 89.

International Organization for Standardization. 1981. Liquid Flow Measurement in Open Channels - Part 1: Establishment and Operation of a Gauging Station. ISO 1100/1-1981 (E).

United States Department of the Interior, Geology Survey. 1977. National Handbook of Recommended Methods for Water-Data Acquisition. Reston, V.A.

ALBERTA FOREST SERVICE WATERSHED MANAGEMENT
FIELD AND LABORATORY METHODS

PART 3

WATER QUALITY FIELD
SAMPLING PROCEDURES

by

A.M.-K. Nip and R.A. Hursey

5
c
5

TABLE OF CONTENTS

GENERAL INTRODUCTION	1
1. INTRODUCTION	2
2. SAFETY CONSIDERATIONS	3
2.1 Toxicity	3
2.2 Physical Safety	4
3. QUALITY CONTROL	7
3.1 General	7
Sampling Location	7
Sample Replication	7
Equipment and Supplies	8
3.2 Sample Contamination	8
4. EQUIPMENT LIST	11
4.1 Suspended Sediment Samples	11
4.2 Hydrochemistry Samples	12
4.3 Biological Oxygen Demand	13
4.4 Stream Temperature	13
5. PREPARATION FOR FIELD WORK	15
6. FIELD PROCEDURE	16

6.1	Choosing the Measurement Location	16
	Dissolved Oxygen	17
	Suspended Sediment and Turbidity	18
	pH, Conductivity and Other Chemical Parameters	19
	Stream Temperatuer	19
6.2	Field Notes	20
6.3	Suspended Sediment Sampling	20
	DH-48 Depth Integrating Suspended Sediment Sampler	21
	Grab or Dip Sampling	25
	Isco Model 1680 Water Sampler	26
	Isco Model 1680 Water Sampler Operating Instructions	28
	Isco Model 2100 Water Sampler Operating Instructions	37
6.4	Hydrochemistry Samples	40
6.5	Dissolved Oxygen	42
	Introduction	42
	Quality Control	42
	Equipment List for Sampling with the YSI Dissolved Oxygen Meter	43
	Preparation for Field Work - YSI Oxygen Meter	43
	Procedure	43

Equipment List for Winkler Analysis	45
Preparation for Field Work - Winkler	
Analysis Reagents	46
Standardization	48
Procedure	49
6.6 Stream Temperature	50
7. ANALYSIS AND REPORTING	51
Interpretation of Water Quality Printout	
Tables	58
Additional Information in the Header	63
Reporting	64
8. CLEANUP AND STORAGE	65
GENERAL REFERENCES	67

LIST OF ILLUSTRATIONS

Figure	Page
1. The DH-48 Depth-Integrating Hand Sampler	22
2. Top View of Sample Bottle Tub	27
3. Suction Line Assembly	29
4. Model 1680 Pump with Outer Case Half Removed ...	30
5. Model 1680 Pump with 12 vdc Supply Connector ...	32
6. Model 1680 Control Panel	33
7. Model 2100 Control Panel	38
8. YSI Dissolved Oxygen Meter	44
9. Form FLU 502/(REV 1/86) Instructions for Collecting Water Samples	52
10. Data Form	53
10a. Hydrometric Survey Form	54
11. Isco Sampling Instructions	55
11a. Isco Sampling Data Form	56
12. Sediment Concentration Form	57
13. Example of Computer Printout of Water Quality Data	59

GENERAL INTRODUCTION

The collection of hydrometric, water quality and hydrometeorologic information is a complex task. A variety of instruments and measurement methods are required to produce a record of hydrologic inputs and outputs for a watershed basin.

There is a growing awareness and recognition that standardization of data acquisition methods is required to ensure data comparability, and to allow comparison of data analyses.

To ensure acceptable quality of data, agreement must be reached among the operating, contributing and user agencies on methods to be used in measuring and sampling data. The purpose of this manual is to assist those involved in the field of data acquisition by outlining methods, practices and instruments which are reliable and recognized by the International Organization for Standardization.

1. INTRODUCTION

The term water quality refers to the acceptability of a given water supply for a specific use (i.e. fish habitat, domestic and industrial use, etc.). Impurities that can be found in water include dissolved gases, chemical elements, inorganic chemical compounds, organic chemical compounds, suspended soil, pesticides, micro-organisms such as bacteria and fungi, and pieces of plants and animals. The presence or absence of these constituents determine the quality of the water.

All natural water contains some impurities such as dissolved oxygen and carbon dioxide. Many are desirable and are often considered to improve water quality for certain purposes. Others are poisonous to humans and other life forms, may cause disease or illness or may impart an unpleasant taste or odor to the water.

The purpose of water quality sampling is to aid in determining what is in the water and to aid in locating the source of pollution.

When it is considered that human and other life is totally dependent on adequate amounts of water that does not contain any harmful substances and that the same is true of many of the industries we depend on, it is evident that a knowledge of water quality is one of the most important human concerns.

2. SAFETY CONSIDERATIONS

Collection of water samples often requires wading in streams or walking onto ice-covered streams, so it can be very dangerous work. In addition, some water which has to be sampled can contain materials so toxic that simple contact with the skin can be harmful to health and swallowing it could be fatal.

Safety, then, must be uppermost in the minds of individuals involved in collecting water samples.

2.1 Toxicity

The first safety precaution which should be taken in planning field work is to find out what is known about the water to be sampled. Almost all truly dangerous water in Alberta has been identified, so a check with the records will indicate any special concerns and precautions necessary. However, it must always be kept in mind that new sources of contamination, such as a PCB spill or acid beginning to enter the stream since it has last been sampled, could be present. Therefore, the field crew must look for any signs of serious pollution, such as sick or dead plants or animals, or discoloration of the water, as well as checking publicly available data or information.

Another factor to consider with streams is that the level of flow can drastically influence health hazards from the water. With low flows a steady volume of a contaminant can reach high enough concentration to be toxic even though it is harmless at normal flow levels. On the other hand, high flows, especially from heavy storms, can wash contaminants into the stream which are not present at normal flows.

2.2 Physical Safety

If the field crew must enter the water, go out in a boat or travel over ice to collect samples, they are in some degree of physical danger and are responsible for taking adequate precautions.

For open water, either wading or in a boat, common sense dictates that a suitable personal flotation device should be worn. In addition one person should remain on shore with the equipment to make a rescue if necessary.

When wading in streams with significant depth and current, a harness and rope system should be used which will make it possible for the person on the bank to make a rescue without entering the stream.

When working in cold water, especially on ice and when the air temperature is also cold, a change of dry clothing such as insulated coveralls and wool socks should be readily available for those who may get wet to help reduce the danger of hypothermia.

Any swift current can contain rolling and bouncing rocks along its bed, so protective footwear must be worn. If the streambed cannot be seen clearly a stout wading pole is needed to probe for deep holes.

When proceeding onto ice an ice chisel should be used to strike the ice forcefully ahead of where one is walking. A flowing current can erode the underside of the ice cover without leaving any indication on the surface of the ice. Thus it is not unusual for ice to be weaker over the centre of the current than near the banks.

When ice is covered with snow or has patches of snow on its surface there may be open water covered by a snow bridge. Therefore, the ice chisel must be used to probe both ahead and on either side of the path taken on the ice. Open water can greatly reduce the strength of the surrounding ice so that checking on either side of where one is walking is necessary.

Because much of the strength of ice comes from the water underneath the ice, air pockets should be watched for constantly. If the water level has dropped the ice may have either developed fractures or be unsupported in places. Fractures and thinning of the ice may also result from a rise in water levels.

Where the water has overflowed onto old ice the ice surface may be very unstable. This is a common cause of air pockets and erosion of the ice thickness. Extreme care should be taken when working where overflows have occurred.

As spring approaches, with stronger incident sunshine and warming air, the strength of the ice can change considerably during the course of the day under marginal ice conditions. Therefore, it is never enough to check the ice only once and then assume it is safe for several hours.

3. QUALITY CONTROL

3.1 General

NOTE SMOKING IS PROHIBITED WHILE WORKING WITH WATER SAMPLES, OR WHEN HANDLING ANY SUPPLIES OR EQUIPMENT USED TO COLLECT AND ANALYSE THE SAMPLES.

The two chief concerns in water quality sampling are: first, that the sample is representative of the water quality parameter of concern; and second, that the samples are not contaminated or allowed to deteriorate before they are analysed.

Sampling Location. Samples should always be taken at the same location each time to allow the detection of changes in water quality parameters over time. The general procedure for establishing a sampling site is discussed under Choosing the Measurement Location in Section 6 of this manual.

In most cases the location for water quality sampling will be at a stream gauging station.

Sample Replication. As a minimum, duplicate samples should be taken for each water quality parameter. Often it is desirable to collect more than two samples because of statistical considerations. Duplicate samples allow for one sample to act

as a backup in case of accidental breakage, contamination or a check on laboratory analysis.

Equipment and Supplies. All equipment, instruments and supplies must be kept clean and in good working order at all times and be handled with care. Records should be kept of all repairs and adjustments to any equipment and instruments, such as current meters, and noted on the field notes. The importance of this is that recalibration or adjustment of instruments can influence the baseline against which the water quality sample is being judged.

3.2 Sample Contamination

Every effort must be made to ensure that samples are not contaminated in any way. If they are contaminated they are useless and the sampling must be repeated, if possible. Often it is not possible to collect a sample to replace the one which has been contaminated, so carelessness can lead to wasted effort and even the failure of a project.

There are a number of simple factors and procedures which can be used to greatly reduce the probability of sample contamination. The following are minimum recommendations:

1. Field measurements should always be taken at the site when the samples are collected. These measurements should

never be taken on the same water samples which will be returned to the laboratory for analysis.

2. The data acquisition officer must keep careful field notes, including observations concerning any unusual conditions such as excessive algal growth, organic debris, unusual color or odor, any evidence of fish kills or evidence of damage to aquatic and benthic plants and animals.

3. Water sample bottles should only be employed to collect water samples. Bottles that have been used in the laboratory to store concentrated reagents should never be used as sample containers.

4. All sample bottles to be used for collecting samples in the field should be cleaned with phosphate-free detergent (Extram 300) using a bottle brush, rinsed three times with distilled water and then allowed to air dry. After the bottles have dried in the air (this must be in a dust-free environment) the bottles should be sealed with plastic caps to ensure that they are not contaminated before they are used.

5. Sample bottles must be stored in a clean environment away from dust, dirt, fumes and grime.

6. The inner portion of sample bottles should not be touched with bare hands, gloves or anything else which might be a source of contamination.

7. After samples have been collected, parafilm wrap should be used to seal the paper caps to prevent contamination of samples analysed for organic¹ compounds.

8. Water samples must never be permitted to stand in the sun. They must be stored in a cool place. Insulated coolers are recommended.

9. Water samples must be shipped to the laboratory without delay.

10. Do not include large non-homogeneous particles such as leaves and detritus in the sample.

¹ Aluminum foil, rather than parafilm, is recommended for organic samples. If in doubt, check with your analytical lab before sampling.

4. EQUIPMENT LIST

All equipment listed in Sections 4.1 Velocity - Area Sites: Wading Techniques, and 4.2 Velocity - Area Sites: Measurement Through Ice must be taken to the sampling site. Any water quality data collected are useless unless accompanied by stream discharge measurement.

4.1 Suspended Sediment Samples

Bottles. The type, number and size of bottles required depends upon the objective and design of the sampling program. Under most circumstances it is preferable to collect two 500 ml samples.

Labels. Labels are required to record the station location, date, time, whether it is sample A or B, and gauge height. This information may be recorded on either paper caps or masking tape. Paper caps and labels must be kept in self-sealing plastic bags or containers before they are used to prevent them from becoming contaminated.

Paper Caps. Paper caps are used to record information as described above under "Labels". They also act as a seal to prevent evaporation or leakage of the sample.

DH - 48 Sampler and Rod. This sampler is the recognized standard sampler for obtaining suspended sediment samples.

Glass Bottles. The glass bottles which are specially fitted for the DH - 48 Sampler are required when it is used. Spare bottles should be taken to the field in case of breakage during transport.

4.2 Hydrochemistry Samples

Bottles. The type, number and size of bottles required depends upon the objective and design of the sampling program. Under most circumstances it is preferable to collect two 500 ml samples.

Labels. Labels are required to record the station location, date, time, whether it is sample A or B, and gauge height. This information may be recorded on either paper caps or masking tape. Paper caps and labels must be kept in self-sealing plastic bags or containers before they are used to prevent them from becoming contaminated.

Paper Caps. Paper caps are used to record information as described above under "Labels". They also act as a seal to prevent evaporation or leakage of the sample.

4.3 Biological Oxygen Demand

(a more current term is biochemical oxygen demand)

Biological Oxygen Demand Bottles. Biological Oxygen Demand (BOD) bottles (300 ml capacity) are specially designed for collecting samples for analysis of biological oxygen demand.

Semi-rigid Plastic Tubing. Fifteen centimetres of this tubing, with an inside diameter of approximately four millimetres, is required. The tubing is used to allow air to move out as the bottle is filled.

Wire. Approximately 15 to 29 cm of wire is needed. The wire is tied to the BOD bottle and the plastic tubing.

String. Approximately 50 cm of string is needed to lower the BOD bottle into the pool.

Manganous Sulphate and Alkali - Iodide - Azide Solutions. These solutions are used to preserve the samples.

Pipette or Eye Dropper. One of these (one millilitre capacity) is required to pipette the preservative solutions into the samples.

4.4 Stream Temperature

Thermometer. A calibration thermometer (certified ASTM or NABS)

with a precision of 0.1C is preferred. The thermometer must be enclosed within a protective casing during transport to prevent breakage.

3.5 Preparation for Field Work

Based on the type and number of samples to be collected, consult the appropriate Equipment List and make sure that all equipment and supplies which may be needed are available in sufficient quantities and in proper working condition.

Pack all supplies and equipment for transport to the field in such a way that they will not be damaged or contaminated in transit.

6. FIELD PROCEDURE

2 The following procedures are designed to ensure that the samples collected are representative of the parameter to be analysed and that the samples are not contaminated. In addition, general field notes are required to aid the data analyst in interpreting the data once the samples have been analysed.

6.1 Choosing the Measurement Location

The usual procedure is to take all samples at or near the stream gauging station. The sampling location may vary depending on what physico-chemical parameters are of interest. The sampling location must also be in a zone where representative samples for the intended purpose can be easily taken.

Four major categories which are usually of interest are: dissolved oxygen; suspended sediment or turbidity; pH, conductivity and other chemical parameters; and stream temperature.

2

Dissolved Oxygen. Dissolved oxygen is one of the most important constituents of water required by aquatic life. In most cases, dissolved oxygen does not become a critical, or limiting factor in determining survival of the species. However, in some circumstances the amount of dissolved oxygen available may determine the ability of a particular species to survive. Certain aquatic insects as well as fish require highly oxygenated water to survive, while other biota can easily adapt to poorly oxygenated water.

Two factors which are important in determining the ability of water to mix with and hold atmospheric oxygen are water temperature and turbulence.

Stream temperature is an important factor in determining the ability of the water to hold oxygen. Cooler water has a higher oxygen holding capacity than warmer water.

Water turbulence such as is found in riffles mixes atmospheric oxygen with the water, allowing oxygen absorption to occur. On the other hand, still water such as is found in pools does not aid oxygen absorption by mixing.

Thus, because it is important to monitor a sampling location where oxygen is likely to become a limiting or critical factor for a species, the best location for obtaining a dissolved oxygen sample would be the center part of a pool.

Suspended Sediment or Turbidity. Sediment in streams is one of Alberta's major pollutants to the stream environment. Various land use disturbances cause sediment to be washed into the stream, i.e. logging, recreation, oil and gas exploration, and grazing.

When sampling for sediment or turbidity in streams there are two types of sources to be considered: point sources, where the source of the problem can be pinpointed and identified, such as an ephemeral draw or a road crossing a stream; and non-point sources, where the source of the problem cannot be pinpointed, such as a logged area or a recreation area. The choice of where to take the samples is different for point sources than for non-point sources.

1. For point sources, where the input of the pollutant is pinpointed, one sample is usually collected above the source and one sample is collected below the source so that a comparison can be made to document the severity of the problem.

In point source sampling the sample from below is collected first, from far enough downstream of the source to allow complete mixing of the pollutant. This distance is usually from 100 to 300 m depending on the size and turbulence of the stream. The sample from above the point

source can then be collected about 10 to 20 M. above the source.

2. For non-point sources samples are collected at one place, usually at the outlet of the stream carrying the pollution load from unknown sources or a series of known but diffuse sources.

Samples should not be collected in pools where sediment has an opportunity to settle out of the water as it slows, but from the midstream portion of a riffle of moderate velocity where the water is well mixed and turbulent.

pH, Conductivity, and other Chemical Parameters. The sampling location may vary depending on the objectives of the sampling program. For most purposes water samples must be collected from the midstream portion of a riffle, where adequate mixing of the water can be expected.

Stream Temperature. Stream temperature is an important factor influencing the survival and growth of aquatic life. All species have a certain optimal and critical temperature for growth. If the critical temperature is exceeded it may become fatal to some species. Stream temperature should be measured from the midstream portion of a riffle.

6.2 Field Notes

When first arriving on the site where the samples will be taken the data acquisition officer must take detailed notes concerning the conditions at the site. Vital information in water quality sampling includes excessive algal growth, organic debris and unusual color or odor to the water.

A rule of thumb for general field notes is to write down everything you see about the site during the course of the work and any problems encountered in taking the sample. If information in the notes is irrelevant it can be ignored during analysis, but if the analysis turns up unexpected information it is likely that the only way to explain the information will be found in well-kept general field notes.

NOTE Before collecting the sample record the station location, date, time, whether sample A or B, and gauge height.

6.3 Suspended Sediment Sampling.

1. In nearly all instances the suspended sediment discharge is measured at, or as near as possible to the stream gauging station. Ideally a sampling site should be selected where the velocity and turbulence are great enough to transport sediment particles in suspension.
2. Ensure that the sample is taken from a well-mixed zone of the stream.
3. Although various samplers have been developed to collect suspended sediment samples, the U.S. DH-48 depth integrating suspended sediment sampler (Figure 1) is considered the standard for collecting stream water for sediment analysis. Consequently, the DH-48 sampler should be used to calibrate the ISCO automatic water sampler by simultaneously sampling with both instruments.

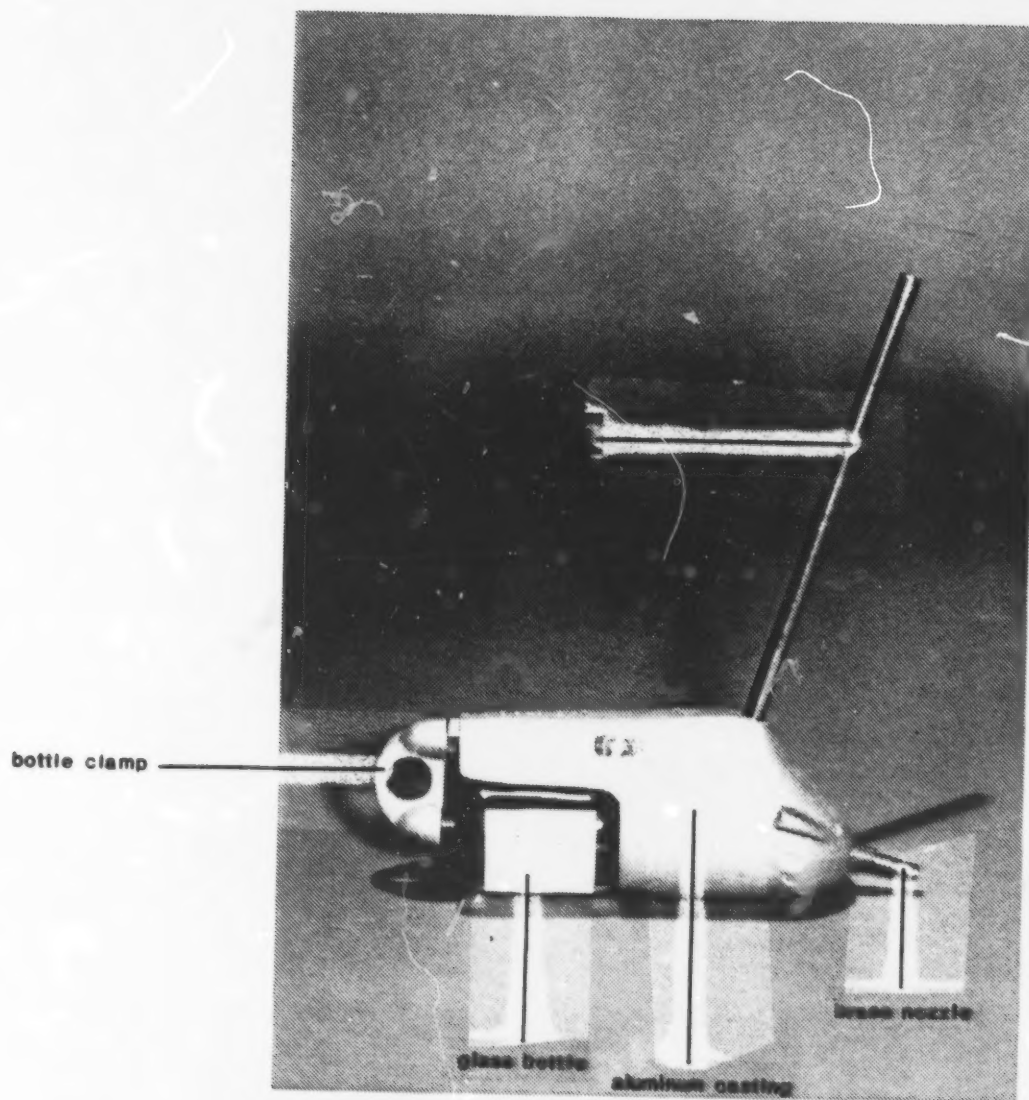


Fig. 1. DH-48 DEPTH INTEGRATING HAND SAMPLER.

8

DH-48 Depth Integrating Suspended Sediment Sampler. The DH-48 sampler consists of a streamlined ALUMINIUM CASTING which encloses the SAMPLE BOTTLE. The sampler is supported by a round WADING ROD.

An INTERCHANGEABLE BRASS NOZZLE, threaded to permit hand assembly into the ALUMINIUM CASTING, projects upstream and provides the intake passage for the sample.

Round 480 mL BOTTLES are used as sample containers. The BOTTLE CLAMP is rotated by hand to allow for insertion of a SAMPLE BOTTLE into the SAMPLER. The BOTTLE CLAMP is then rotated again back to its normal closed position. This seals the SAMPLE BOTTLE head against a rubber gasket within the SAMPLER head.

1. Screw the round WADING ROD into the top of the ALUMINIUM CASTING. Screw the INTERCHANGEABLE NOZZLE (usually the largest nozzle is used) into the front end of the SAMPLER.

2. Before collecting the sample, record the station location, date, time, whether it is sample A or B and the gauge height on a label or paper cap.

3. A clean bottle should be used for each separate sediment sample.

4. Hold the WADING ROD vertically and lower the SAMPLER at a uniform rate from the water surface to the streambed, then instantly reverse the direction of travel of the SAMPLER and raise it at a uniform rate.

NOTE It is essential that a uniform rate of travel be maintained both in lowering and raising the sample bottle because the sample is to represent an equal distribution of the sediment concentration from the water surface to the streambed.

5. Check to see if the volume of the sample is within the permissible range (350 to 400 mL). If it is, rotate the BOTTLE CLAMP and remove the SAMPLE BOTTLE. Seal the SAMPLE BOTTLE with a paper cap and a plastic cap.

6. If the volume of the sample is not within the permissible range the sample should be discarded and a new sample taken. If no fresh SAMPLE BOTTLES are available rinse the used SAMPLE BOTTLE thoroughly with distilled water and collect a new sample.

Grab or Dip Sampling. Grab or dip sampling is a non-recognized method of obtaining suspended sediment samples, and should be used in reduced frequency or totally eliminated where possible. It should be replaced with the DH-48 depth integrated sampler.

NOTE The procedure is similar to that for the DH-48 samples. The bottle is held manually at the same angle as in the DH-48, lowered to the bottom of the stream and then brought up toward the water surface at a uniform rate in both directions. The rate of fill will be much faster (<5 sec.) because of the open bottle. Optimum sample size is approximately 350 to 400 mL. If the sample bottle is over-filled, use a new bottle and repeat the procedure. Whenever possible obtain paired samples at the same location. Paired samples reduce the possibility of error in sampling and analysis, loss or spillage of the sample, and allows for greater representativeness of the sample by averaging results.

ISCO Model 1680 Water Sampler. The sampler consists of five sections which are held together by a series of clamps. The following instructions are adapted from the original ISCO wastewater sampler operating manual. The five sections are:

1. The COVER encloses the mechanical and electrical components of the sampler, protecting them from the elements.
2. The PUMP AND CONTROL SECTION contains the pump mechanism, electronic circuitry and programmable controls.
3. The DISTRIBUTING FUNNEL directs the water into the proper sample bottle.
4. The DISTRIBUTOR PLATE works with the DISTRIBUTING FUNNEL to divert the water to the proper sample bottle, and prevents mixing between the sample bottles.
- 5 The SAMPLE BOTTLE TUB holds the sample bottles.

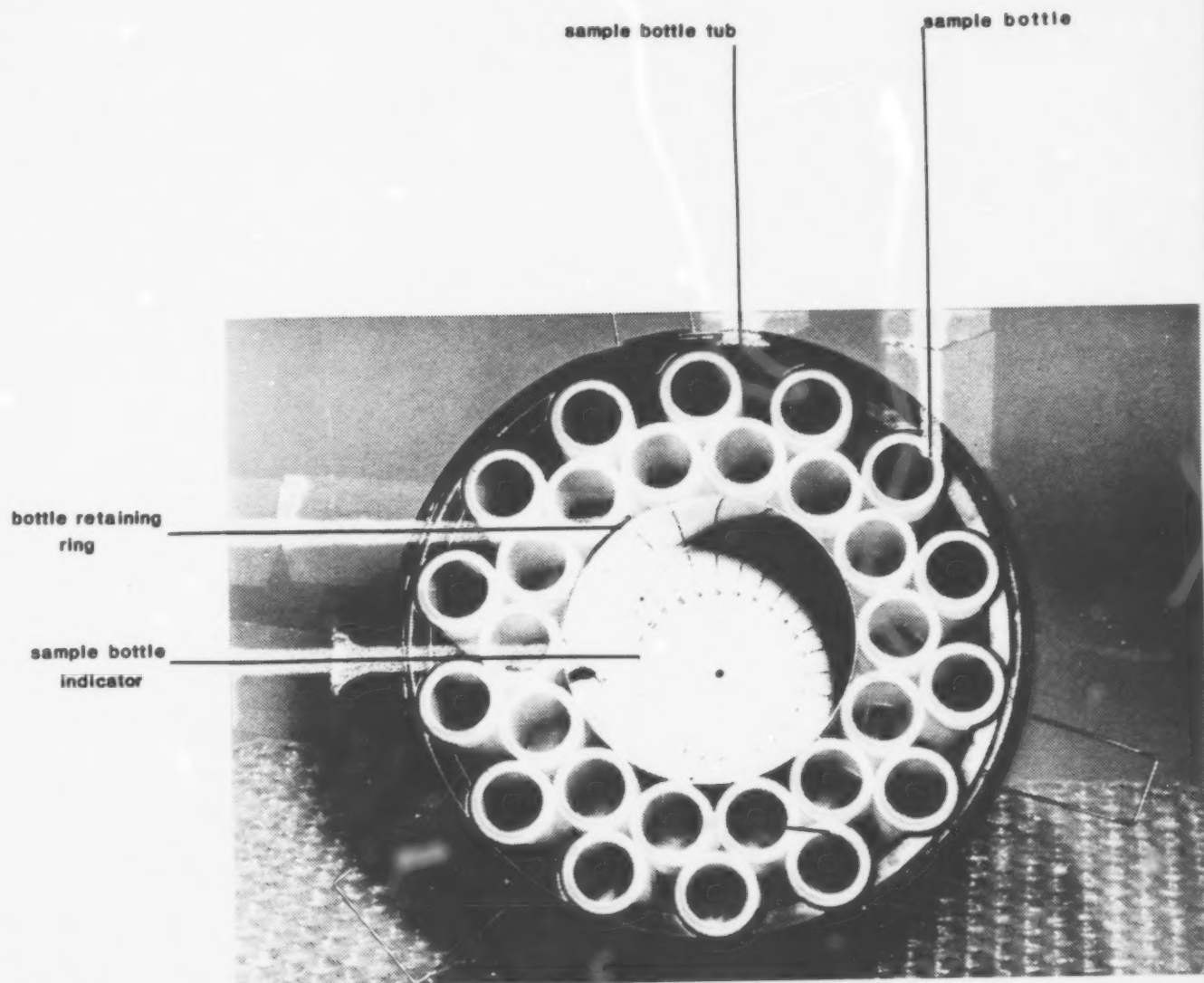


Fig. 2. TOP VIEW OF SAMPLE BOTTLE TUB.

ISCO Model 1680 Water Sampler Operating Instructions.

(newer models such as the 2700 are easier to operate and maintain)

1. Assemble all the polyethylene sample bottles in the SAMPLE BOTTLE TUB. The capacity is 24 bottles (Figure 2) and it must be filled. Remove the caps from the bottles. Insert the BOTTLE RETAINING RING in the centre of the SAMPLE BOTTLE TUB to hold the bottles securely in place.

2. For installation of the 0.8 cm inside diameter SUCTION TUBING (Figure 3), first remove the three PUMP COVER RETAINING SCREWS (Figure 4). Pull the outer pump case straight out from the control box.

Loosen the lower CLAMP and insert the end of the SUCTION TUBE, in which the STEEL FERRULE is installed, into the end of the PUMP AND SUCTION TUBING approximately 1.3 cm as shown in Figure 3. Tighten the lower CLAMP.

Place the pump tubing guide and clamp assembly in the inner pump case so that its groove fits with the semicircular opening in the pump case. Replace the outer pump case so that the PUMP TUBING GUIDE AND CLAMP assembly fit properly into both halves of the pump, and reinstall the three PUMP COVER RETAINING SCREWS.

3. The placement of the SUCTION LINE, the INTAKE and the SAMPLER are all critical to achieve proper results. The

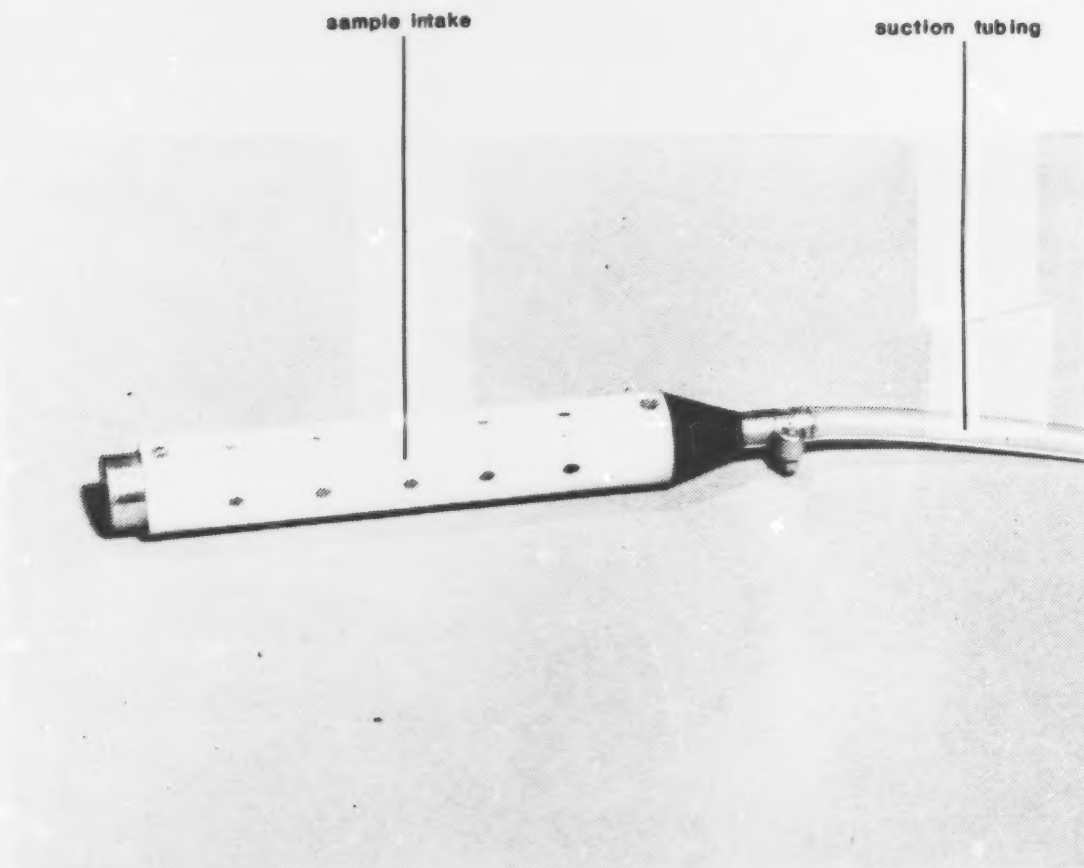


Fig. 3. SUCTION LINE ASSEMBLY.

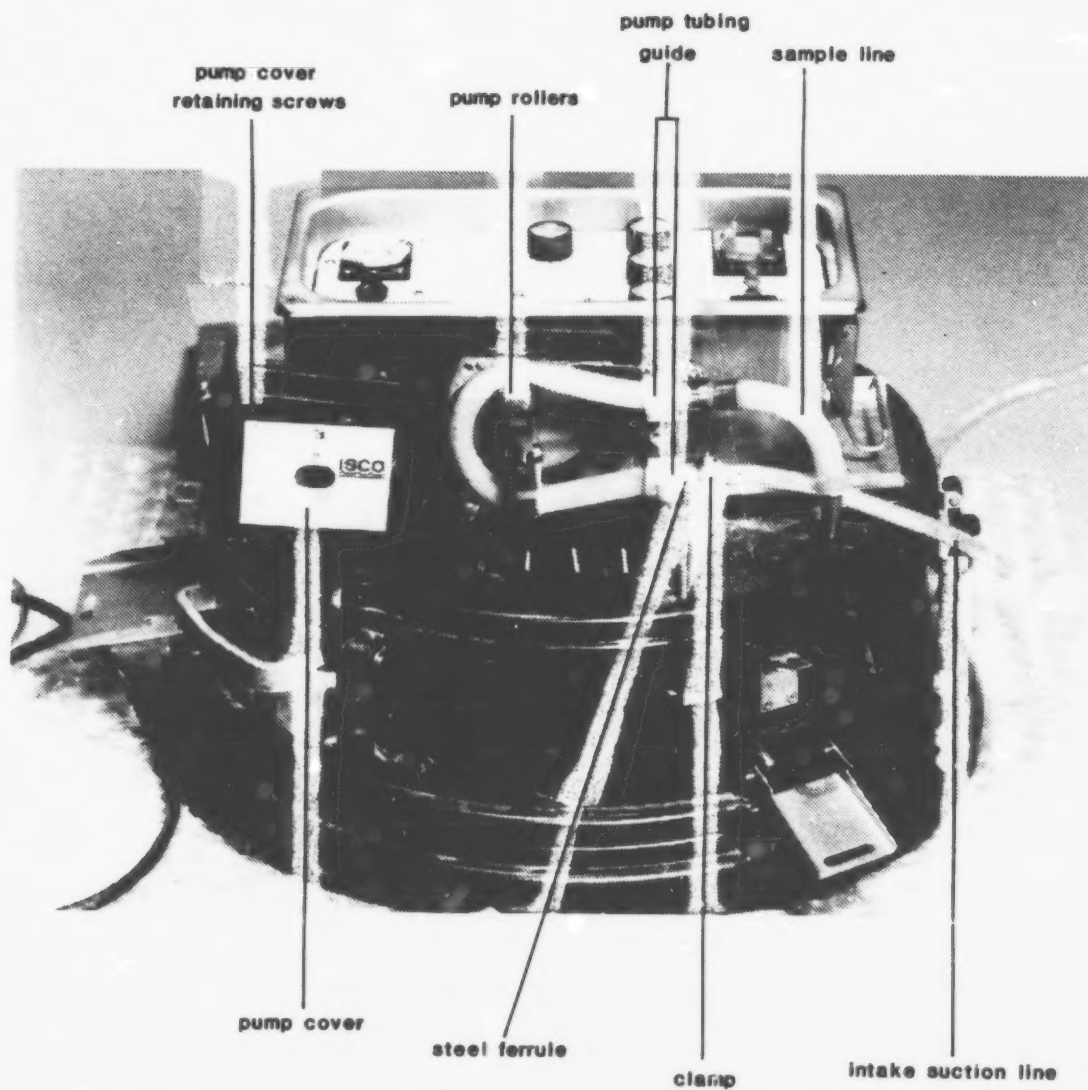


Fig. 4. MODEL 1680 PUMP WITH OUTER CASE HALF REMOVED.

SUCTION LINE from the SAMPLER to the intake point must slope downward to allow complete draining of the SUCTION LINE.

The intake should be placed facing upstream in the main flow of the stream, not in an eddy or at the edge of the flow. The intake should be placed in a vertical position, mid-depth in the stream. A stake should be inserted into the streambed to attach the intake in a proper position and depth. The intake may also be attached to a self-adjusting boom, thus allowing the intake to remain at a constant 0.6 of the total depth beneath the surface of the water. The SAMPLER should be kept within 5° of the horizontal because a large deviation from the horizontal will prevent flow through the DISTRIBUTOR PLATE.

4. The SAMPLER may be powered with an external 12 volt direct current source such as an automotive battery. A connecting cable, as shown in Figure 5, is available for this purpose. Plug the connecting cable into the "12 VDC" connector on the side of the SAMPLER. Then connect the positive and negative leads on the free end of the cable to the proper terminals of the external twelve volt direct current source. The positive lead of the cable can be identified by the red painted clip.

5. Set up the sampling program on the SAMPLER CONTROL PANEL (Figure 6) for model 1680.

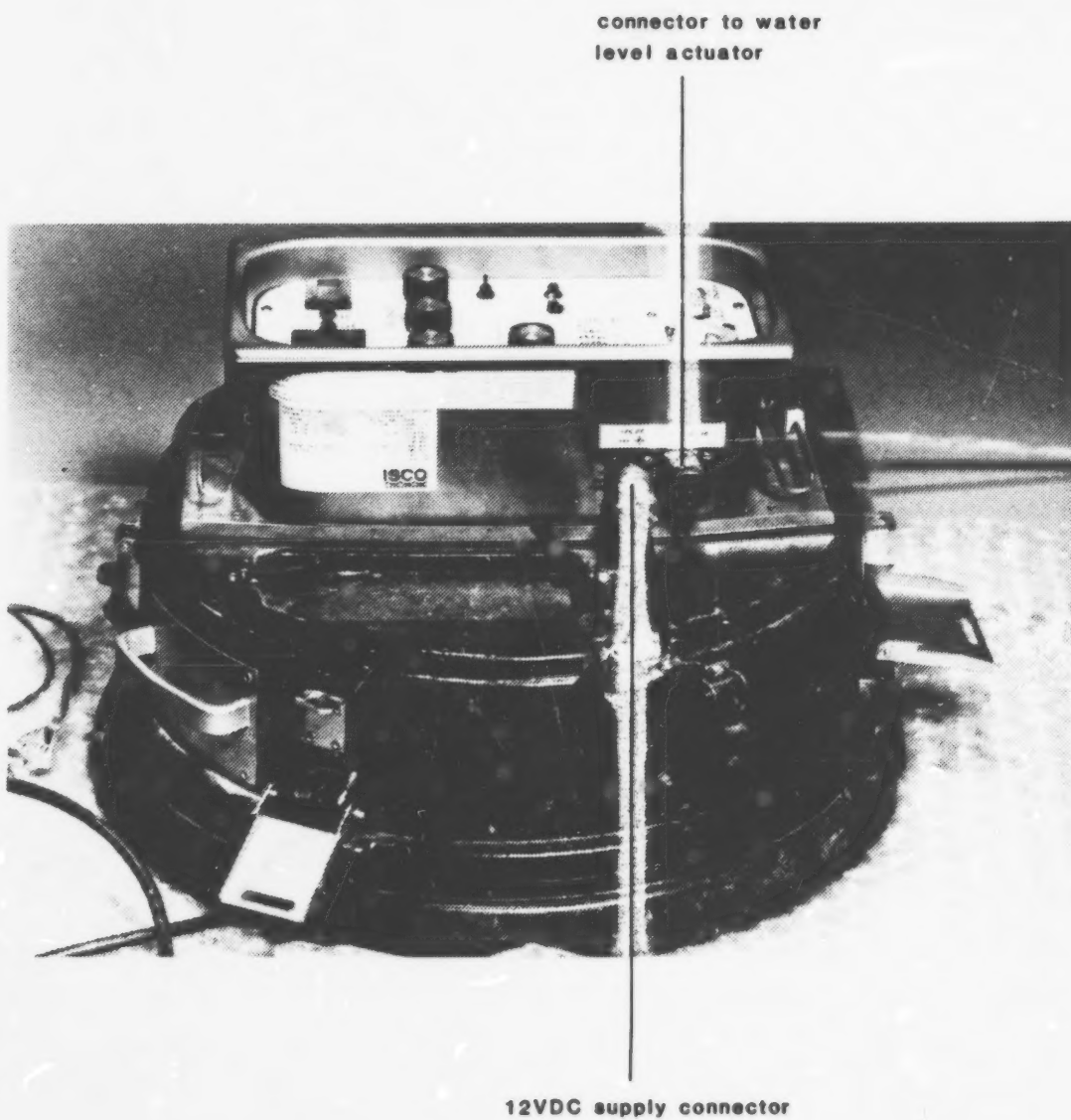


Fig. 5. MODEL 1680 WITH 12 VDC SUPPLY CONNECTOR.

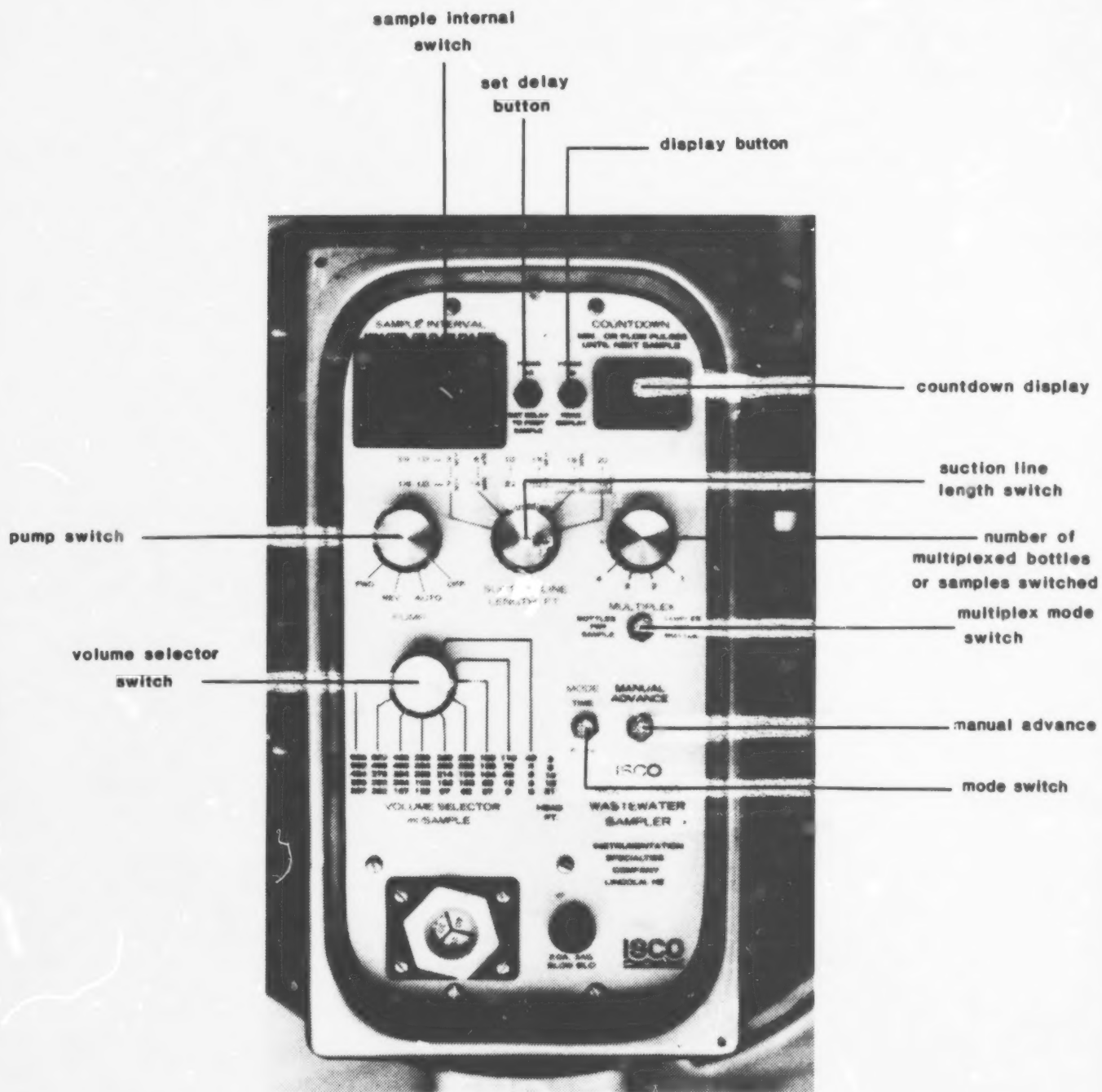


Fig. 6. MODEL 1680 CONTROL PANEL.

The pumping cycle consists of three steps: step one is when the pump rotates in the reverse direction to purge the line; step two is when the pump changes direction to fill the suction line and the sample bottle; and step three when the pump reverses direction to purge the suction line in order to avoid cross-contamination of the samples.

The pump will then shut off and the DISTRIBUTOR FUNNEL will rotate to the position of the next SAMPLE BOTTLE to be filled.

1. Place the PUMP SWITCH in the AUTO position.
2. Use the MANUAL ADVANCE button to advance the DISTRIBUTING FUNNEL to the STANDBY position.
3. Rotate the VOLUME SELECTOR SWITCH to set the desired volume of each sample in millilitres. Note that the volume desired is dependent on the pumping head in use.
4. Set the SUCTION LINE LENGTH SWITCH to the setting corresponding to the physical length of the SUCTION LINE being used.
5. Place the MODE SWITCH in the TIME position.

6. Set multiplex controls (NUMBER OF MULTIPLEXED BOTTLES OR SAMPLE BOTTLE) to "1" and set MULTIPLEX MODE SWITCH to Bottles for Sample.
7. Set the SAMPLE INTERVAL SWITCH to ZERO (000). Note that a non-zero interval must have been present on the switch before it is reset to zero.
8. Using the MANUAL ADVANCE push-button advance the funnel to bottle no. one.
9. Momentarily depress the SET DELAY PUSH-BUTTON. A complete sampling cycle will begin immediately.
10. Set the desired time interval for the remainder of the samples on the SAMPLE INTERVAL SWITCH. This may be set while the first sample is being collected.
11. Momentarily depress the SET DELAY PUSH-BUTTON to set the delay before the first sample has been fully collected.
12. Press the DISPLAY PUSH-BUTTON to verify that the correct delay interval for the second sample has been set.

13. Samples will continue to be collected until the last (24th) bottle has been filled. The sampler will automatically shut off when the last bottle has been filled.

7. Leave all switches in the positions as set out in the instructions above for continuous sampling, and the process will continue until the last (24th) bottle is filled. The sampler will automatically shut itself off after the last bottle has been filled.

ISCO Model 2100 Water Sampler Operating Instructions. The initial setup of the sampler is as given in steps one through four for the Model 1680. To set up the sampling program follow the procedure below (Figure 7).

1. Turn the ON/OFF SWITCH to the ON position.
2. Place the MODE SWITCH in the SET UP position.
3. Press the DISTRIBUTION TUBE SWITCH to the RESET position in order to advance the bottles to the first bottle.
4. Rotate the SUCTION HEAD SWITCH to indicate the proper SUCTION HEAD of the sampler.
5. Set the desired volume per sample in tens of millilitres on the NOMINAL SAMPLE VOLUME SWITCH.
6. Switch the MULTIPLEX NUMBER OF BOTTLES OR SAMPLES SWITCH to the OFF position.
7. Set the desired time interval between samples in minutes on the SAMPLE INTERVAL SWITCH.
8. Place the MODE SWITCH in the TIME position.

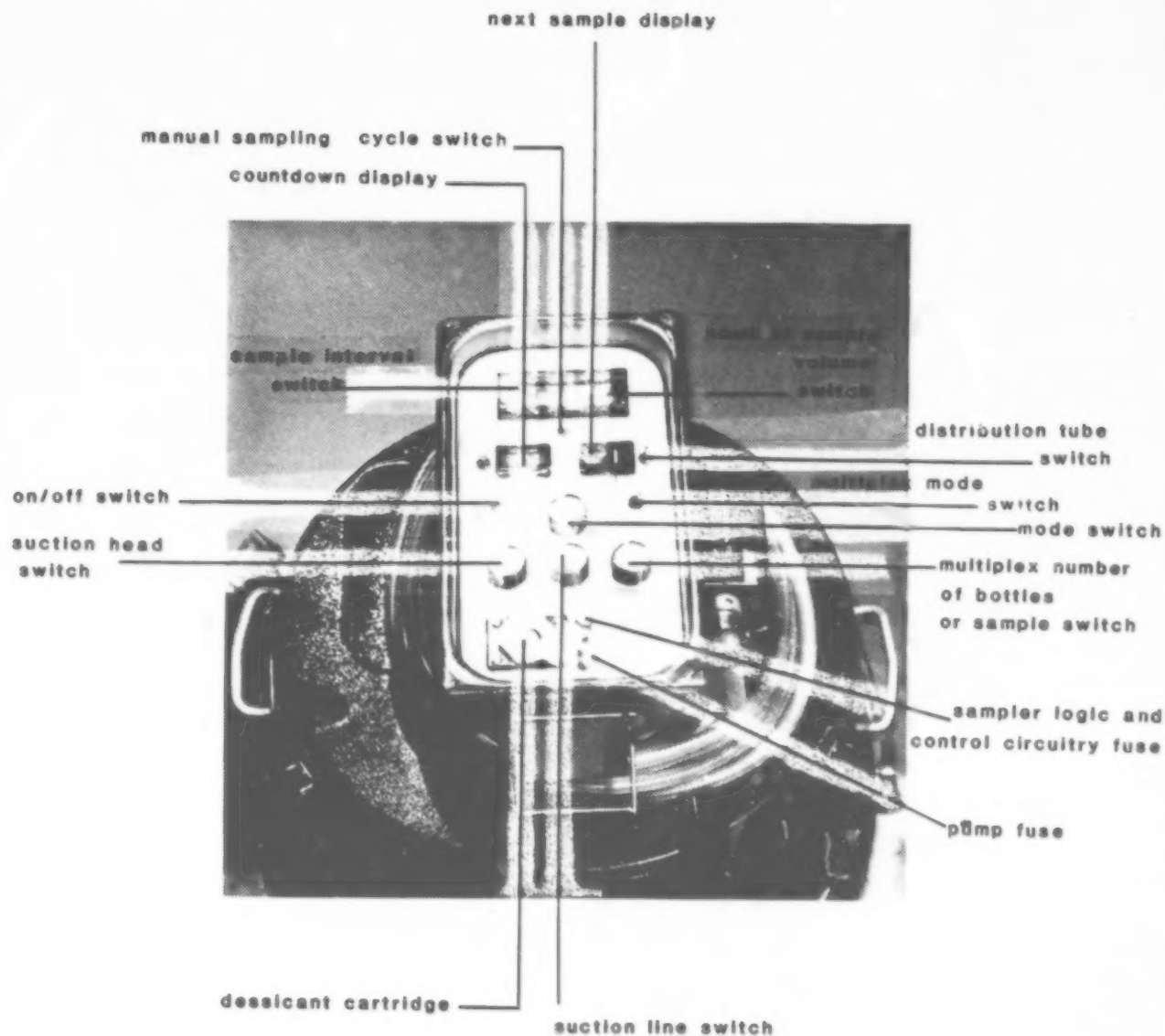


Fig. 7. MODEL 2100 CONTROL PANEL.

9. Momentarily move the MANUAL SAMPLING CYCLE SWITCH to the RESET SAMPLE INTERVAL position. This will cause a sampling cycle to be initiated immediately. Then set the time interval with the SAMPLE INTERVAL SWITCH until the second sample is taken after the interval set in step 7.

10. Press the SET TO READ DISPLAYS PUSH-BUTTON (Figure 7) to verify the status of the sampling as shown on the COUNTDOWN DISPLAY and NEXT SAMPLE DISPLAY.

6.4 Hydrochemistry Samples

1. Record the station location, date, time, sample A or B and gauge height on the paper caps for each bottle.
2. Face the sample bottle upstream when collecting the sample to avoid contamination.
3. The sample bottles should be filled to the top of the bottle and then sealed with parafilm and a paper cap. Rinse the bottle twice with the stream water before taking the actual sample.
4. When preserving samples group all the sample bottles for a given parameter together. Handle all preservatives with caution. Add preservatives quantitatively, being careful to avoid contamination. After the preservatives have been added the bottle should be sealed and then well rinsed on the outside with distilled water.
5. Pack the sample bottles carefully into containers to protect them from sunlight and keep them as cool as possible. The preferred temperature is 4°C.
6. Return the samples to the laboratory as quickly as possible and do the laboratory analysis. If the samples are to be shipped to another laboratory for analysis make

sure that they are kept cool (4C) and away from direct sunlight until shipped.

The Alberta Environmental Centre at Vegreville has guidelines for sampling and preservation of samples. Please contact the Chemistry Wing for details.

6.5 Dissolved Oxygen

Introduction. Dissolved oxygen should be measured in situ with a dissolved oxygen meter, or within three to six hours if preserved samples are brought in from the field for analysis by titration. Both methods are given in this section.

Quality Control. The analysis of dissolved oxygen requires that quality control be of the highest order. For the chemical analysis by the Winkler procedure discussed in this chapter, the reagents must be prepared exactly as specified, and the sampling and analysis procedure followed precisely. The chemical analysis must be done as soon as possible if it is to be of any value whatsoever.

NOTE If the analysis has not been completed within six hours of the time the samples have been collected the work has been wasted.

For the analysis using the YSI Dissolved Oxygen Meter, Model 51B, discussed in this volume, the critical factors are to set the meter to the proper water temperature and elevation.

Equipment List for Sampling with the YSI Dissolved Oxygen Meter

YSI Oxygen Meter

Membrane Kit

Preparation for Field Work - YSI Dissolved Oxygen Meter.

Check that the battery is fully charged and that there is no damage to the meter or accessory equipment.

Procedure.

1. Turn the FUNCTION knob (Figure 8) to "zero scale".
2. Adjust the ZERO SCALE button to read "zero".
3. Turn the FUNCTION knob to "full scale".
4. Adjust the FULL SCALE knob to read "full scale".
5. Turn the FUNCTION knob to "temperature" and set the dial to the temperature of the water using the fresh water scale. Immerse the probe in the water and read the temperature. Record the temperature of the water in your field notes.

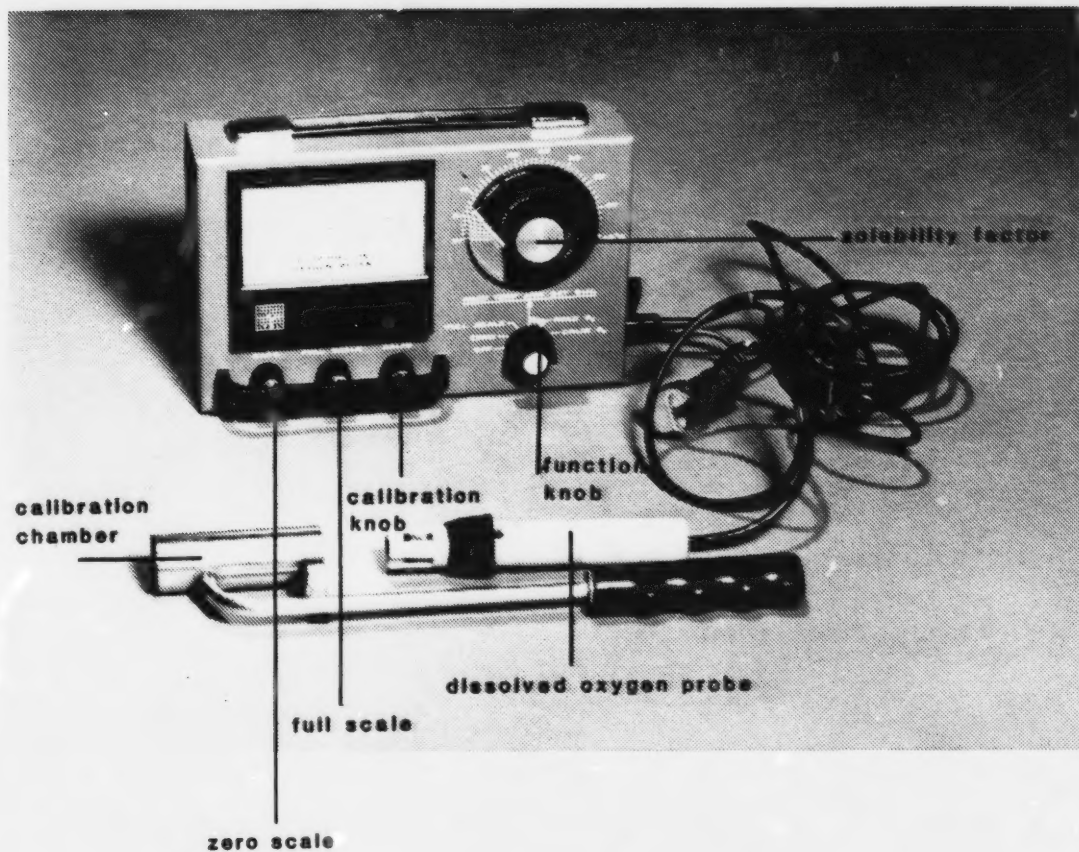


Fig. 8. YSI DISSOLVED OXYGEN METER.

6. Place the probe tightly into a rubber stopper fitted calibration chamber. Immerse the chamber and probe in the water and allow five minutes for the measurement to stabilize. Turn the FUNCTION knob to "calibration" and calibrate the meter by turning the SOLUBILITY FACTOR knob to read the elevation of the sampling location.

7. Turn the FUNCTION knob to read "O₂".

8. Remove the probe from the calibration chamber and insert the probe into the stream. Record the dissolved oxygen as parts per million.

9. Turn off the meter and pack all the equipment for transport.

Equipment List for Winkler Analysis.

BOD Bottles (300 ml)

Semi-rigid plastic tubing

wire

String

Manganous Sulphate

Alkali - Iodide - Azide Solution

Eye Dropper

Preparation for Field Work - Winkler Analysis Reagents. The following reagents are required for the Winkler analysis of dissolved oxygen in water. They must be prepared before the samples are collected in the field because the analysis of the samples must be done as soon after they are collected and preserved as possible. The procedures below have been adapted from American Public Health Association, et al. (1971).

1. Concentrated (6M) sulphuric acid H_2SO_4 .
2. 0.025 M potassium dichromate solution. Prepare by first drying the potassium dichromate ($\text{K}_2\text{Cr}_2\text{O}_7$).

Dry for two hours at 103°C before preparing the solution. Dissolve 1.226 g of potassium dichromate in one liter of distilled water volumetrically. This is the standard (0.1M) solution.

3. Manganous sulphate (use $\text{MnSO}_4 \cdot 2\text{H}_2\text{O}$) solution. Dissolve 480 g of manganous sulphate of the hydration noted in distilled water, filter, and dilute to one litre with distilled water.

NOTE The manganous sulphate solution should not give a color with starch when added to an acidified solution of potassium iodide.

4. Alkali-iodide-azide reagent.

NOTE This reagent is carcinogenic. Wear rubber gloves while preparing the reagent and while doing titrations in the field. None of this reagent should be allowed to come in contact with living tissue.

To prepare the reagent, dissolve 10.0 g of sodium azide (NaN_3) in 500 mL of distilled water. Add 480.0 g of sodium hydroxide (NaOH) and 750.0 g of sodium iodide (NaI) and stir until dissolved. There will be a white turbidity due to sodium carbonate formed in the mixture but this is not important.

CAUTION: Do not acidify this solution because toxic hydrazoic acid fumes may be produced.

5. Starch solution. Use either an aqueous solution or soluble starch powder mixtures. To prepare an aqueous starch solution, dissolve two grams of laboratory-grade soluble starch and 0.2 g of salicylic acid (as a preservative) in 100 mL of hot distilled water.

6. Standard Sodium Thiosulphate($\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$)

This is the titrating solution used to determine the dissolved oxygen. Prepare by dissolving 6.205 g of sodium

thiosulphate in distilled water. Add 1.5 mL of 6 M sodium hydroxide or 0.4 g solid sodium hydroxide and dilute to 1.0 L with distilled water in a volumetric flask.

Standardization. The standard sodium thiosulphate solution prepared above must be standardized to 0.025 M by the following procedure.

1. Dissolve approximately 2.0 g of potassium iodide (KI), free from iodate, in an erlenmeyer flask with 100 to 150 mL of distilled water. Add 1.0 mL of 6 M sulphuric acid to 9.0 mL of distilled water, then 20.0 mL of standard 0.025 M potassium dichromate solution. Dilute to 200 mL and titrate the liberated iodine in the potassium iodide solution with the 0.025 M sodium thiosulphate titrant solution, adding starch toward the end of the titration when a pale straw color is reached.

When the solutions are of equal strength, 20.0 mL of 0.025 M thiosulphate should be required. If not, adjust the thiosulphate solution to 0.025 M. This is done by calculating the volume of 0.1 M stock sodium thiosulphate solution that is diluted to 1.0 L to get exactly 0.025 M standard sodium thiosulphate solution.

$$\text{Vol. of stock sodium thiosulphate} = \frac{\text{Vol. of Titrant} \times 250}{20.0}$$

From this the 0.025 M thiosulphate solution can be prepared for the determination of dissolved oxygen.

Procedure.

1. At the sampling location place a plastic tube into a 300 mL BOD bottle. Tie a piece of wire so the plastic tube is held rigidly against the top dome of the bottle. This will allow air to move out through the tube as the bottle is being filled.
2. Lower the bottle to the surface and position it so that water will overflow into it. Bring the bottle to the surface and place a glass stopper in the bottle to seal it. Record the stream temperature.
3. To preserve the sample add the following reagents immediately.

YOU MUST WEAR RUBBER GLOVES WHILE TITRATING THESE REAGENTS.

- A. First add 1.0 mL of the manganous sulphate solution.
- B. Then add 1.0 mL of the alkali-iodide-azide solution.

When adding these preservatives hold the pipette tips just above the liquid surface.

4. Stopper the sample bottles carefully to exclude air bubbles and then mix by inverting the bottle a few times.

Keep the samples cool and in the shade until they are returned to the laboratory for titration.

6.6 Stream Temperature

Insert a calibration thermometer (NABS or ASTM grade) into a riffle area. Allow the thermometer to equilibrate with the water, then record the temperature to the nearest 0.1C.

7. ANALYSIS AND REPORTING

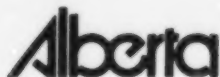
No scientific work is completed until the data collected have been analysed and properly reported. This should be done as soon as the crew returns from the field to headquarters and the equipment has been properly unloaded and is drying.

To facilitate a data base management system, a special form was created, FLU 502/(REV 1/86), shown in Figures 9, 10 and 10a. It has space for all data that may be collected by watershed field personnel on the top half, and space for laboratory results on the bottom half. Each form has three copies, and the back of the last page has space for streamflow data. The instruction page with the form should be self-explanatory.

Because the information required for samples collected by ISCO samplers is much less than the FLU 502(REV 1/86) form, a separate form, FLU 502A (Figures 11 and 11a) was devised to reduce costs and paperwork.

A separate form (Figure 12) was also prepared for sediment concentration data.

A detailed explanation of the terms appearing on these forms is given in the Section "Interpretation of Water Quality Printout Tables" which immediately follows this this section.



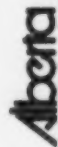
FLU 502A
(Rev 1/86)

INSTRUCTIONS FOR COLLECTING WATER SAMPLES

FORESTRY
Forest Land Use Branch
Watershed Management

1. For GRAB SAMPLES or DH48, take a clean bottle and rinse twice with water to be collected. Sample should be collected midstream, and where adequate mixing occurs. If organic debris is present, discard and take another sample. Leave 3 cm. air space and replace cap tightly. Attach sticky label X.1 to single sample bottle and X.2 to second sample of pair. Alternatively, the X.1 sample can be a grab and X.2 can be a DH48 for comparison.
2. For DISCRETE ISCO samples, ship as is or shake well and transfer to shipping bottle immediately. Attach X.1 label. Indicate sampling interval. For COMPOSITE ISCO, indicate number integrated (multiplex mode). Based on sampling interval, indicate correct Date and Time for each sample on respective form.
3. At point sources, downstream samples are collected before upstream samples. Enter the number 3 to indicate a downstream sample, and number 4 for upstream. (ei.: X.13 and X.23 for downstream pair, and X.14 and X.24 for upstream pair.)
4. Complete form with all necessary information for each bottle or pair of bottles. Insert top 2 parts in envelope in case. Keep bottom part for your records and record streamflow on back.
5. When case is full, or within one month, send case of samples to Watershed Management in Edmonton for analysis.
6. Once analyzed, the top part will be sent back to originating Forest. Watershed Management in Edmonton will retain second part and enter data on computer file.

Fig. 9. FORM FLU 502 (REV 1/86) INSTRUCTIONS FOR COLLECTING WATER SAMPLES.



FORESTRY Forest Land Use Branch - Watershed Management

12501 WATER SAMPLING FORM

STATION		LOCATION	
OBSERVER		PURPOSE ☐ POINT ☐ NONPOINT	
DATE	TIME	2	3
Mo	Day	hrs	mins
SAMPLE TYPE		4	
1. GRAB		NUMBER INTEGRATED	
2. COMPOSITE / SCO		5	
3. DISCRETE / SCO		6	
4. DRY		7	
5. FLOW CONDITION		8	
6. FLOW CONDITION		9	
7. STABLE		10	
8. RISING		11	
9. PEAK		12	
10. PRE FLOW		13	
11. PEAK FLOW		14	
12. PRE FLOW		15	
13. PEAK FLOW		16	
14. PRE FLOW		17	
15. PEAK FLOW		18	
16. PRE FLOW		19	
17. PEAK FLOW		20	
18. PRE FLOW		21	
19. PEAK FLOW		22	
20. PRE FLOW		23	
21. PEAK FLOW		24	
22. PRE FLOW		25	
23. PEAK FLOW		26	
24. PRE FLOW		27	
25. PEAK FLOW		28	
26. PRE FLOW		29	
27. PEAK FLOW		30	
28. PRE FLOW		31	
29. PEAK FLOW		32	
30. PRE FLOW		33	
31. PEAK FLOW		34	
32. PRE FLOW		35	
33. PEAK FLOW		36	
34. PRE FLOW		37	
35. PEAK FLOW		38	
36. PRE FLOW		39	
37. PEAK FLOW		40	
38. PRE FLOW		41	
39. PEAK FLOW		42	
40. PRE FLOW		43	
41. PEAK FLOW		44	
42. PRE FLOW		45	
43. PEAK FLOW		46	
44. PRE FLOW		47	
45. PEAK FLOW		48	
46. PRE FLOW		49	
47. PEAK FLOW		50	
48. PRE FLOW		51	
49. PEAK FLOW		52	
50. PRE FLOW		53	
51. PEAK FLOW		54	
52. PRE FLOW		55	
53. PEAK FLOW		56	
54. PRE FLOW		57	
55. PEAK FLOW		58	
56. PRE FLOW		59	
57. PEAK FLOW		60	
58. PRE FLOW		61	
59. PEAK FLOW		62	
60. PRE FLOW		63	
61. PEAK FLOW		64	
62. PRE FLOW		65	
63. PEAK FLOW		66	
64. PRE FLOW		67	
65. PEAK FLOW		68	
66. PRE FLOW		69	
67. PEAK FLOW		70	
68. PRE FLOW		71	
69. PEAK FLOW		72	
70. PRE FLOW		73	
71. PEAK FLOW		74	
72. PRE FLOW		75	
73. PEAK FLOW		76	
74. PRE FLOW		77	
75. PEAK FLOW		78	
76. PRE FLOW		79	
77. PEAK FLOW		80	
78. PRE FLOW		81	
79. PEAK FLOW		82	
80. PRE FLOW		83	
81. PEAK FLOW		84	
82. PRE FLOW		85	
83. PEAK FLOW		86	
84. PRE FLOW		87	
85. PEAK FLOW		88	
86. PRE FLOW		89	
87. PEAK FLOW		90	
88. PRE FLOW		91	
89. PEAK FLOW		92	
90. PRE FLOW		93	
91. PEAK FLOW		94	
92. PRE FLOW		95	
93. PEAK FLOW		96	
94. PRE FLOW		97	
95. PEAK FLOW		98	
96. PRE FLOW		99	
97. PEAK FLOW		100	
98. PRE FLOW		101	
99. PEAK FLOW		102	
100. PRE FLOW		103	
101. PEAK FLOW		104	
102. PRE FLOW		105	
103. PEAK FLOW		106	
104. PRE FLOW		107	
105. PEAK FLOW		108	
106. PRE FLOW		109	
107. PEAK FLOW		110	
108. PRE FLOW		111	
109. PEAK FLOW		112	
110. PRE FLOW		113	
111. PEAK FLOW		114	
112. PRE FLOW		115	
113. PEAK FLOW		116	
114. PRE FLOW		117	
115. PEAK FLOW		118	
116. PRE FLOW		119	
117. PEAK FLOW		120	
118. PRE FLOW		121	
119. PEAK FLOW		122	
120. PRE FLOW		123	
121. PEAK FLOW		124	
122. PRE FLOW		125	
123. PEAK FLOW		126	
124. PRE FLOW		127	
125. PEAK FLOW		128	
126. PRE FLOW		129	
127. PEAK FLOW		130	
128. PRE FLOW		131	
129. PEAK FLOW		132	
130. PRE FLOW		133	
131. PEAK FLOW		134	
132. PRE FLOW		135	
133. PEAK FLOW		136	
134. PRE FLOW		137	
135. PEAK FLOW		138	
136. PRE FLOW		139	
137. PEAK FLOW		140	
138. PRE FLOW		141	
139. PEAK FLOW		142	
140. PRE FLOW		143	
141. PEAK FLOW		144	
142. PRE FLOW		145	
143. PEAK FLOW		146	
144. PRE FLOW		147	
145. PEAK FLOW		148	
146. PRE FLOW		149	
147. PEAK FLOW		150	
148. PRE FLOW		151	
149. PEAK FLOW		152	
150. PRE FLOW		153	
151. PEAK FLOW		154	
152. PRE FLOW		155	
153. PEAK FLOW		156	
154. PRE FLOW		157	
155. PEAK FLOW		158	
156. PRE FLOW		159	
157. PEAK FLOW		160	
158. PRE FLOW		161	
159. PEAK FLOW		162	
160. PRE FLOW		163	
161. PEAK FLOW		164	
162. PRE FLOW		165	
163. PEAK FLOW		166	
164. PRE FLOW		167	
165. PEAK FLOW		168	
166. PRE FLOW		169	
167. PEAK FLOW		170	
168. PRE FLOW		171	
169. PEAK FLOW		172	
170. PRE FLOW		173	
171. PEAK FLOW		174	
172. PRE FLOW		175	
173. PEAK FLOW		176	
174. PRE FLOW		177	
175. PEAK FLOW		178	
176. PRE FLOW		179	
177. PEAK FLOW		180	
178. PRE FLOW		181	
179. PEAK FLOW		182	
180. PRE FLOW		183	
181. PEAK FLOW		184	
182. PRE FLOW		185	
183. PEAK FLOW		186	
184. PRE FLOW		187	
185. PEAK FLOW		188	
186. PRE FLOW		189	
187. PEAK FLOW		190	
188. PRE FLOW		191	
189. PEAK FLOW		192	
190. PRE FLOW		193	
191. PEAK FLOW		194	
192. PRE FLOW		195	
193. PEAK FLOW		196	
194. PRE FLOW		197	
195. PEAK FLOW		198	
196. PRE FLOW		199	
197. PEAK FLOW		200	
198. PRE FLOW		201	
199. PEAK FLOW		202	
200. PRE FLOW		203	
201. PEAK FLOW		204	
202. PRE FLOW		205	
203. PEAK FLOW		206	
204. PRE FLOW		207	
205. PEAK FLOW		208	
206. PRE FLOW		209	
207. PEAK FLOW		210	
208. PRE FLOW		211	
209. PEAK FLOW		212	
210. PRE FLOW		213	
211. PEAK FLOW		214	
212. PRE FLOW		215	
213. PEAK FLOW		216	
214. PRE FLOW		217	
215. PEAK FLOW		218	
216. PRE FLOW		219	
217. PEAK FLOW		220	
218. PRE FLOW		221	
219. PEAK FLOW		222	
220. PRE FLOW		223	
221. PEAK FLOW		224	
222. PRE FLOW		225	
223. PEAK FLOW		226	
224. PRE FLOW		227	
225. PEAK FLOW		228	
226. PRE FLOW		229	
227. PEAK FLOW		230	
228. PRE FLOW		231	
229. PEAK FLOW		232	
230. PRE FLOW		233	
231. PEAK FLOW		234	
232. PRE FLOW		235	
233. PEAK FLOW		236	
234. PRE FLOW		237	
235. PEAK FLOW		238	
236. PRE FLOW		239	
237. PEAK FLOW		240	
238. PRE FLOW		241	
239. PEAK FLOW		242	
240. PRE FLOW		243	
241. PEAK FLOW		244	
242. PRE FLOW		245	
243. PEAK FLOW		246	
244. PRE FLOW		247	
245. PEAK FLOW		248	
246. PRE FLOW		249	
247. PEAK FLOW		250	
248. PRE FLOW		251	
249. PEAK FLOW		252	
250. PRE FLOW		253	
251. PEAK FLOW		254	
252. PRE FLOW		255	
253. PEAK FLOW		256	
254. PRE FLOW		257	
255. PEAK FLOW		258	
256. PRE FLOW		259	
257. PEAK FLOW		260	
258. PRE FLOW		261	
259. PEAK FLOW		262	
260. PRE FLOW		263	
261. PEAK FLOW		264	
262. PRE FLOW		265	
263. PEAK FLOW		266	
264. PRE FLOW		267	
265. PEAK FLOW		268	
266. PRE FLOW		269	
267. PEAK FLOW		270	
268. PRE FLOW		271	
269. PEAK FLOW		272	
270. PRE FLOW		273	
271. PEAK FLOW		274	
272. PRE FLOW		275	
273. PEAK FLOW		276	
274. PRE FLOW		277	
275. PEAK FLOW		278	
276. PRE FLOW		279	
277. PEAK FLOW		280	
278. PRE FLOW		281	
279. PEAK FLOW		282	
280. PRE FLOW		283	
281. PEAK FLOW		284	
282. PRE FLOW		285	
283. PEAK FLOW		286	
284. PRE FLOW		287	
285. PEAK FLOW		288	
286. PRE FLOW		289	
287. PEAK FLOW		290	
288. PRE FLOW		291	
289. PEAK FLOW		292	
290. PRE FLOW		293	
291. PEAK FLOW		294	
292. PRE FLOW		295	
293. PEAK FLOW		296	
294. PRE FLOW		297	
295. PEAK FLOW		298	
296. PRE FLOW		299	
297. PEAK FLOW		300	
298. PRE FLOW		301	
299. PEAK FLOW		302	
300. PRE FLOW		303	
301. PEAK FLOW		304	
302. PRE FLOW		305	
303. PEAK FLOW		306	
304. PRE FLOW		307	
305. PEAK FLOW		308	
306. PRE FLOW		309	
307. PEAK FLOW		310	
308. PRE FLOW		311	
309. PEAK FLOW		312	
310. PRE FLOW		313	
311. PEAK FLOW		314	
312. PRE FLOW		315	
313. PEAK FLOW		316	
314. PRE FLOW		317	
315. PEAK FLOW		318	
316. PRE FLOW		319	
317. PEAK FLOW		320	
318. PRE FLOW		321	
319. PEAK FLOW		322	
320. PRE FLOW		323	
321. PEAK FLOW		324	
322. PRE FLOW		325	
323. PEAK FLOW		326	
324. PRE FLOW		327	
325. PEAK FLOW		328	
326. PRE FLOW		329	
327. PEAK FLOW		330	
328. PRE FLOW		331	
329. PEAK FLOW		332	
330. PRE FLOW		333	
331. PEAK FLOW		334	
332. PRE FLOW		335	
333. PEAK FLOW		336	
334. PRE FLOW		337	
335. PEAK FLOW		338	
336. PRE FLOW		339	
337. PEAK FLOW		340	
338. PRE FLOW		341	
339. PEAK FLOW		342	
340. PRE FLOW		343	
341. PEAK FLOW		344	
342. PRE FLOW		345	
343. PEAK FLOW		346	
344. PRE FLOW			

Current Meter No. _____

[illegible]

54

ISCO SAMPLES INSTRUCTIONS

I Field Staff:

1. Complete one copy of FLU 502/84 for first ISCO sample with all necessary information.
2. Use the same sample number on FLU 502 A.
3. Column 1: Date: Month Day eg. 721
4. Column 2: Time: eg. 1400
5. Column 3: SI - Sample Interval in hours - 2,3,4, etc.
6. Column 4: Type - always 3 = ISCO
7. Column 5: NI - Number Integrated means number of samples per bottle - multiplex mode.
8. Column 6: Sample Number - already done except enter 3 in center blank for downstream samples, 4 in center blank for upstream samples, 0 in center blank for single site samples.
9. Columns 7 to 15: Do not apply, but are included to facilitate data entry into computer.
10. Keep photocopy for your records and send original with samples to lab.

II. Lab Staff:

11. Column 16: Sediment Concentration (mg/L)
12. Column 17: Turbidity (JTU or NTU)
13. Column 18: Conductivity (micromhos)
14. Column 19: pH
15. Once columns 16 to 19 are complete and data entered into computer, keep photocopy for our records and send original back to forest.

Fig. 11. ISCO SAMPLING INSTRUCTIONS.

ISCO SAMPLES

FLU 502A

Forest: _____ Station: _____ Sample Number: _____

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
D A T E	T I M E	S I	T Y P E	N I	N U M B E R	F C O N	S G H T	F L T K	F L O S W	P K S L W	P F T M P	S T E M P	A T E M P	P R E C	C O N C	T U R B	C O N D	P H
MD	HRS	HRS													MG/L	JTU	UMHOS	
					.1_2	x	x	x	x	x	x	x	x	x				
					.1_3													
					.1_4													
					.1_5													
					.1_6													
					.1_7													
					.1_8													
					.1_9													
					.1_10													
					.1_11													
					.1_12													
					.1_13													
					.1_14													
					.1_15													
					.1_16													
					.1_17													
					.1_18													
					.1_19													
					.1_20													
					.1_21													
					.1_22													
					.1_23													
					.1_24													
					.1_25													
					.1_26													
					.1_27													
					.1_28													

Fig. 11a. ISCO SAMPLING DATA FORM.

SEDIMENT CONCENTRATION (ISCO)

DATE ANALYSED:

FOREST:

ANALYSIS BY:

SITE or NO.:

DATE:

TIME:

Plate No.

Tare +
Sediments (mg)

Tare (mg)

Sediments (mg)

Volume of
Water (L)

Concentration
(mg/L)

REMARKS:

Fig. 12. SEDIMENT CONCENTRATION FORM .

Interpretation of Water Quality Printout Tables. The computer printout format (Figure 13) was designed to meet the needs of the Alberta Forest Service streamflow monitoring program. The contents of each column are explained by column number.

1. DATE refers to the day and month the sample was taken.
e.g. 518: 5 = May, 18 = 18th day; so the figure 518 in column 1 indicates a sampling date of May 18th.
2. TIME is given using the 24 hour clock: 1300 is 1:00 p.m.
3. SI refers to Sample Interval and indicates the time between samples in hours. This is also referred to as the sampling frequency. This information is given when automatic samplers were used.
4. TY indicates the TYpe of sample taken using the following code: 1 is a grab/dip; 2 is a stage; 3 is automatic composite; 4 is automatic discrete; and 5 is for DH48 isokinetic sampler.
5. NI stands for the Number of samples Integrated, or composited, in one sample bottle.
6. NUMBER is the sample number. Files up to 1983 generally contain numbers with a zero decimal. Where the

**** GPSREDROCK84

RED ROCK CREEK GRANDE PRAIRIE FOREST
 PHASE 3 CODE : ASC16E3 AREA : 3960 HA
 LOCATION : 4-63-9-W6 LAT/LONG :
 WATER QUALITY DATA: 1984

DATE TIME SI TY NI NUMBER FC0N STAGE
 HR

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	523	1430	..	1	..	5581.10	1	..	1.003	..	..	..	..	..	6.5	1.2	85
2	529	1300	..	1	..	5796.10	1	..	1.153	..	..	..	..	..	4.3	1.7	70
3	601	1100	..	1	..	6178.10	1	..	1.132	..	..	..	..	17.4	9.2	3.7	65
4	605	..	1	3	2	5809.10	..	..	1.013	..	..	..	..	..	28.7	8.6	70
5	605	..	1	3	2	5810.10	..	..	1.013	..	..	..	..	..	31.6	8.8	70
6	605	..	1	3	2	5811.10	..	..	1.013	..	..	..	..	..	34.3	10.0	65
7	605	..	1	3	2	5812.10	..	..	1.013	..	..	..	..	..	36.3	98.0	70
8	605	..	1	3	2	5813.10	..	..	1.013	..	..	..	..	..	38.2	9.3	70
9	605	1200	..	1	..	5807.10	1	..	1.003	..	..	..	..	..	3.6	1.5	70
10	605	1200	..	1	..	5816.10	1	..	1.003	..	..	..	..	..	8.3	2.5	70
11	608	2000	..	1	..	6163.10	1	..	1.003	..	..	..	..	..	14.0	2.2	50
12	608	2000	..	1	..	6184.10	2	..	1.003	..	..	..	..	..	28.8	4.6	55
13	608	1700	..	1	..	6189.10	2	..	1.003	..	..	..	..	..	16.3	2.3	55
14	608	1800	..	1	..	6188.10	4	..	1.003	..	..	..	..	..	20.8	4.5	60
15	611	1145	..	1	..	6194.10	4	..	1.003	..	..	..	..	..	4.8	1.3	70
16	611	1145	..	1	..	6185.10	4	..	1.003	..	..	..	..	..	4.8	1.3	70
17	613	1330	..	1	..	6557.10	4	..	1.003	..	..	..	..	..	9.3	3.7	70
18	616	1030	..	1	..	6205.10	2	..	1.003	..	..	..	..	..	6.1	2.2	80
19	619	1300	..	1	..	6229.10	4	..	1.003	..	..	..	..	..	6.1	2.2	80
20	624	1130	..	1	..	6207.10	1	..	1.003	..	..	..	..	..	1.8	7.0	105
21	629	1200	..	1	..	6596.10	1	..	1.003	..	..	..	..	..	3.0	2.4	..
22	629	1200	..	1	..	6597.10	1	..	1.003	..	..	..	..	..	3.0	2.4	..
23	707	1530	..	1	..	6270.10	1	..	1.003	..	..	..	..	..	1.5	1.0	..
24	719	1400	..	1	..	7179.10	1	..	1.003	..	..	..	..	..	1.5	1.0	..
25	731	1430	..	1	..	7215.10	2	..	1.003	..	..	..	..	..	1.5	1.0	..
26	817	1500	..	1	..	6564.10	1	..	1.003	..	..	..	..	..	79.6	36.0	..
27	823	1300	..	1	..	6729.10	1	..	1.003	..	..	..	..	..	2.4	..	240
28	828	1400	..	1	..	6729.10	1	..	1.003	..	..	..	..	..	1.2	..	250
29	920	1400	..	1	..	6758.10	4	..	1.003	..	..	..	..	..	1.6	..	..
30	920	1400	..	1	..	6994.10	4	..	1.003	..	..	..	..	..	1.1	..	..
31	920	1400	..	1	..	6994.20	4	..	1.003	..	..	..	..	..	1.9	..	..
32	920	1400	..	1	..	6996.10	4	..	1.003	..	..	..	..	..	92.7	81.0	100
33	920	1400	..	1	..	6996.20	4	..	1.003	..	..	..	..	..	94.6	80.0	100
34	921	1400	..	1	..	6997.20	4	..	1.003	..	..	..	..	..	6.7	5.2	100
35	921	1400	..	1	..	6995.10	4	..	1.003	..	..	..	..	..	1544.3	1000.0	115
36	921	1400	..	1	..	6995.20	4	..	1.003	..	..	..	..	..	1363.6	830.0	110

RATING CURVE : FLOW = 11.109 + STAGE*1.868
 COMMENTS : RICHARD WATER LEVEL RECORDER, BELFORT-SANGANO RAIN GAUGES, ISCO WATER SAMPLER ON SITE.

Fig. 13. COMPUTER PRINTOUT OF WATER QUALITY DATA.

decimal is 0.3 it indicates a sample taken downstream of a point source such as a bridge. If it is 0.4 it indicates an upstream sample. The two numbers should be sequential, such as 5 000.3 and 5 000.4.

Files beginning with those for 1984 have a different number code, which is interpreted as follows:

5 000.1 is a single sample.

5 001.1 followed in the column by 5 001.2 indicates a paired sample taken at the same spot for computing an average.

5 002.13 followed in the column by 5 003.14 indicates a single sample taken downstream (0.13) and one taken upstream (0.14) of a point source such as a culvert.

5 004.13 and 5 004.23 indicates paired downstream samples.

5 005.14 and 5 005.24 indicates paired upstream samples.

For example, the last four numbers in column 6 should appear sequentially, but the date and time should be the same for all samples:

<u>DATE</u>	<u>TIME</u>	<u>NUMBER</u>
518	1015	5004.13
518	1015	5004.23
518	1015	5005.14
518	1015	5005.24

7. FCON stands for Flow Condition. The code is: 1 for stable; 2 for falling; 3 for rising; 4 for dry; and 5 for peak.

8. STAGE refers to the stage height at the date and time of measurement.

9. AC stands for the actual flow taken. An asterisk (*) in the column indicates an actual instantaneous stream flow measurement was taken. Two dots (..) indicates that the flow was estimated from a rating curve.

10. FLOW is the stream flow in cubic metres per second. If column 9 contains an asterisk (*) the flow is an actual measurement of instantaneous flow. If a stage is given in column 8 the flow is a rating curve estimate. If no stage is given in column 8 the flow is either an interpolated estimate or a Stevens Recorder estimate, depending on the gauge used. These estimates are discussed below under the heading of Streamflow Information.

11. PEAK refers to the peak stage recorded between the recorded visit and a previous one. It is not the peak stage at the time of the recorded visit.

This column was originally intended for use by the Bow/Crow Forest staff in their crest gauge program. The peak stage recorded is used to estimate flows between dates when actual measurements were taken. It is a substitute for those creeks without Stevens recorders where flow data are desired.

12. FLOW or PFLOW is the stream flow at the peak stage in cubic metres per second as generated from a rating curve.

13. STEMP is the stream temperature in degrees centigrade.

14. ATEMP is the air temperature in degrees centigrade.

15. PREC is the precipitation. The precipitation recorded is how much has fallen between the recorded and a previous visit where precipitation was recorded at the site. It is not the amount of precipitation that fell on the date of the recorded visit.

16. CONC is the concentration of suspended solids in mg/L.

17. TURB is the turbidity of the sample in Jackson Turbidity Units (JTU) or Nephelometric Turbidity Units (NTU).

18. COND is the conductivity of the water in micromhos per centimetres.

NOTE This figure is not always representative of the conductivity at the time of sampling. Samples are not always analysed immediately, nor stored at cold temperatures. Delays of up to three weeks or more can occur before analysis is done.

19. pH is occasionally analysed but is not entered on the printout at present.

Additional Information in the Header. (Figure 13)

The Phase 3 Code is a six-level alphanumeric map code ranging from ocean drainage to sub-watershed.

Area is the area in hectares of the watershed above the monitoring site.

Location is the legal subdivision: section, township, range, meridian.

Lat/Long are the latitude and longitude coordinates.

Rating Curve is the regression equation used to predict flow from stage height.

Reporting.

All data on these forms are entered in University of Alberta Amdahl computer files for each forest and stream location just as the data appear on the form. Once each annual file is complete and correct, hard copy listings (printouts) are compiled and mailed to the respective forests. The data is published annually by the Alberta Forest Service, Forest Land Use Branch. Alberta Environment also collects water quality data and the data is recorded in the NAQUADAT system (maintained by Environment Canada).

8. CLEANUP AND STORAGE

As soon as the equipment is brought back from the field it must be carefully dried and cleaned to prevent corrosion during storage.

Check all equipment for wear or damage, especially the current meter, wading rod and tape measure. If repairs are required make sure they are done immediately so the equipment will be ready to use the next time it is needed.

Check the CURRENT METER as described in section 5.1 before storage. Remove the CONTACT CHAMBER CAP and lubricate all moving gears with silicone oil or RISILONE oil each week. Tighten the CONTACT CHAMBER CAP after lubrication.

Disconnect the battery from the equipment to prevent corrosion. Recharge the battery if it is rechargeable. Check the charge of the battery to ensure it is not discharged before placing it in storage.

Replace equipment such as forms, sample bottles and any other materials that may be needed for the next water quality sampling field trip.

Carefully pack and store all equipment and supplies in clean dry conditions. It is good practice to go through the equipment list (section 4) as the equipment is placed in storage to make sure that nothing will be missing or found to be broken the next time it is necessary to prepare for field work. Should a hydrologic event (sudden rise in water level as a result of a storm event) occur which must be measured on short notice there will not be time to repair or replace equipment and supplies.

GENERAL REFERENCES

American Public Health Association, American Water Wastes Association, and Water Pollution Control Federation, 1980. Standard Methods for the Examination of Water and Wastewater. 15th edition.¹ American Public Health Association, New York. 874p.

Gray, D. M. and Male, D. H. Editors. 1981. Handbook of Snow: Principles, Processes, Management and Use. Pergamon Press.

Herschy, R., 1970 The Magnitude of Errors at Flow Measurement Stations. Vol. 1. Proceedings, Symposium on Hydrometry, Koblenz. Sept. 1970. pp. 109- 131. IAHS Paris Publication No. 89.

International Organization for Standardization. 1981. Liquid Flow Measurement in Open Channels - Part 1: Establishment and Operation of a Gauging Station. ISO 1100/1-1981 (E).

United States Department of the Interior, Geology Survey. 1977. National Handbook of Recommended Methods for Water-Data Acquisition. Reston, V.A.

¹ A 16th Edition is now available



**ALBERTA FOREST SERVICE WATERSHED MANAGEMENT
FIELD AND LABORATORY METHODS**

PART 4

**WATER QUALITY - ANALYTICAL
CHEMISTRY PROCEDURES**

by

A.M.-K. Nip and R.A. Hursey



TABLE OF CONTENTS

GENERAL INTRODUCTION	1
1. INTRODUCTION	2
2. SAFETY CONSIDERATIONS	2
3. QUALITY CONTROL	3
4. EQUIPMENT LIST	3
5. PREPARATION FOR LABORATORY WORK	3
6. LABORATORY PROCEDURE	4
6.1 Order to Perform Chemical Analysis	4
6.2 Conductivity	5
Introduction	5
Quality Control	5
Procedure for the Metrohm Model 587	
Conductivity Meter	8
Procedure for YSI Model 33 S-C-T	
Conductivity Meter	13
Calibration	13
Procedure	15

6.3	pH Measurement	16
	Introduction	16
	Quality Control	16
	Equipment List	18
	Procedure for Metrohm Model 588 pH Meter ..	19
	Procedure for the Corning pH Meter Model 3D.	24
6.4	Turbidity	27
	Introduction	27
	Quality Control	28
	Procedure	28
6.5	Suspended Solids (Total Non-Filterable Solids)	33
6.6	Total and Phenolphthalein Alkalinity	37
	Introduction	37
	Quality Control	37
	Reagents	38
	Procedure	39
	Calculations	40
6.7	Dissolved Calcium	44
	Introduction	44
	Preparation of Reagents	44
	Procedure	47
	Calculations	48
6.8	Dissolved Oxygen	49
	Calculations	49

7. COLLECTION AND PRESERVATION OF WATER SAMPLES FOR	
ALBERTA ENVIRONMENTAL CENTRE, VEGREVILLE	50
7.1 Introduction	50
7.2 Quality Control	50
7.3 Procedure	51
GENERAL REFERENCES	54

LIST OF ILLUSTRATIONS

Figure	Page
1. E587 Conductometer	9
1a. E587 Conductometer continued.....	10
1b. E587 Conductometer Probe	11
2. YSI Conductivity Meter.....	14
3. E588 pH Meter.....	20
3a. E588 pH Meter continued.....	21
3b. E588 pH Probe	22
4. Corning Model 3D Portable pH Meter.....	25
5. Turbidity Meter.....	29
6. Chemical Analysis Request.....	52

GENERAL INTRODUCTION

The collection of hydrometric, water quality and hydrometeorologic information is a complex task. A variety of instruments and measurement methods are required to produce a record of hydrologic inputs and outputs for a watershed basin.

There is a growing awareness and recognition that standardization of data acquisition methods is required to ensure data comparability, and to allow comparison of data analyses.

To ensure acceptable quality of data, agreement must be reached among the operating, contributing and user agencies on methods to be used in measuring and sampling data. The purpose of this manual is to assist those involved in the field of data acquisition by outlining methods, practices and instruments which are reliable and recognized by the International Organization for Standardization.

1. INTRODUCTION

This chapter contains a series of laboratory procedures for analysing water samples. These samples are collected in the field using the procedures in Volumes 2 and 3 of this manual. However, they can be used on samples from any location.

2. SAFETY CONSIDERATIONS

Laboratory safety is something which must always be kept in mind by everyone working in the laboratory. If the laboratory does not already have safety regulations posted where they cannot be easily overlooked, the person in charge of the laboratory should prepare and post such regulations.

The procedures in this chapter involve handling of strong acids and bases. Even the fumes from strong acids and bases can damage the eyes, respiratory system and skin, so appropriate precautions must be taken.

3. QUALITY CONTROL

The procedures in this chapter are quantitative chemical analytical tests. They must be performed using only the best laboratory methods. Concerns for quality control are discussed for each procedure where the concern is particularly important.

4. EQUIPMENT

The appropriate list of equipment and reagents will be included in each procedure as needed. It is assumed that these procedures are to be carried out in a laboratory equipped with the basic chemicals and equipment.

5. PREPARATION FOR LABORATORY WORK

In general, make sure that the laboratory is supplied with the necessary reagents, glassware and instruments before beginning any of the procedures. This is best achieved by reading through the entire procedure before beginning to work.

6. LABORATORY PROCEDURES

6.1 Order to Perform Chemical Analyses

Depending on the number of duplicate samples available and the number of analyses required, a particular order of analyses must be followed.

If pH and conductivity are to be determined from the same water sample the conductivity must be determined before pH. This is because the diffusion of ions from the pH probe may change the conductivity of the water.

If only suspended sediment and turbidity results are required, turbidity must be determined before suspended sediment is determined.

Total alkalinity of the water sample should be determined before total calcium. The reason is the determination of total alkalinity requires the water to be unfiltered. In contrast, the determination of total calcium requires the water to be filtered.

6.2 Conductivity

Introduction.

The conductivity of a water sample is its capacity to convey an electric current. This property is related to the total concentration of ions in the water and is dependent on temperature. Most inorganic acids, bases and salts are good conductors, whereas most of the organic compounds do not dissociate into ions in aqueous solution, and are therefore poor conductors of electric current. Hence, conductivity can be related to the ionic strength of a given solution (water sample).

Reagent grade distilled water has a specific conductance of less than 2.0 microsiemens/cm. If distilled water supplies have a higher conductivity than 2.0 microsiemens/cm they cannot be used.

Quality Control.

1. New probes should be conditioned by immersing the probe in ethanol for two hours.
2. Do not immerse the probe in strong acids or bases.

3. Pre-filtering is not required for metered parameters.
4. Swirl samples before pouring into a disposable beaker.
5. Ensure there are no air bubbles on the contact plates inside the probe.
6. Always standardize with a buffer solution closest to the observed value.
7. Probes are cleaned by ultrasonic bath in a mild solution of lab detergent. Normally the probes are sent to the Alberta Environmental Centre, Water Chemistry Section in Vegreville for cleaning.

If an ultrasonic bath is not available the probes may be cleaned using a three per cent hydrogen peroxide solution. Place the conductivity probe in a 200 ml beaker of hydrogen peroxide solution and allow any organic material adhered to the contact plates to be oxidized and escape as gas.

When the bubbling ceases remove the probe and rinse well with distilled water. Do not allow the probe to be immersed in hydrogen peroxide any longer than necessary. Store the probes in storage tubes filled with distilled water.

8. When using a new standard solution, save some of the old solution to ensure that there is comparability.

9. Do not allow the probes to be exposed to freezing temperatures.

Procedure for the Metrohm Model 587 Conductance Meter. (See Figure 1)

1. Check the condition of the battery. If the battery charge is low do not use it until it is fully recharged. It requires 36 hours for a complete recharging.
2. Use a standard KCl solution. This is available from Alberta Environmental Centre, Vegreville, or any other Alberta Environment analytical chemistry laboratory.
3. Place the sample and the KCl solution in separate 100 ml. beakers. Place the beakers in a constant temperature bath at 25°C and allow their contents to equilibrate to the temperature of the water bath.
4. Rinse the probe with distilled water.
5. Place the conductivity probe in the standard KCl solution.
6. Set the SELECTOR SWITCH to the appropriate range for calibration.

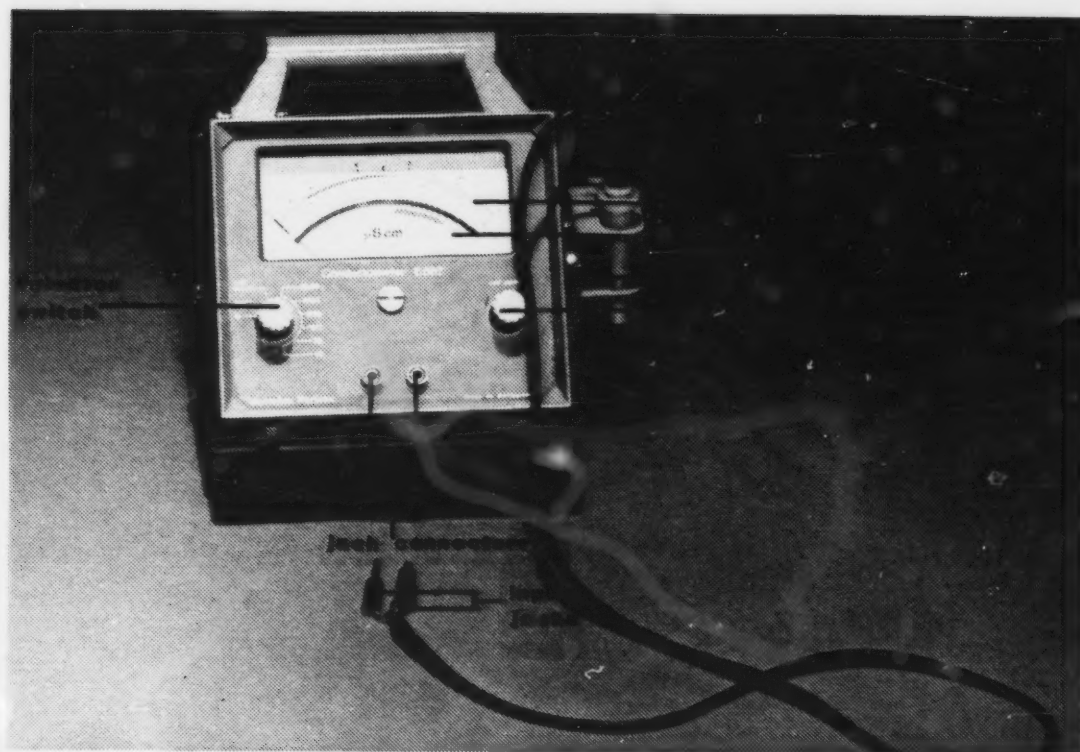


Fig. 1. E587 CONDUCTOMETER.

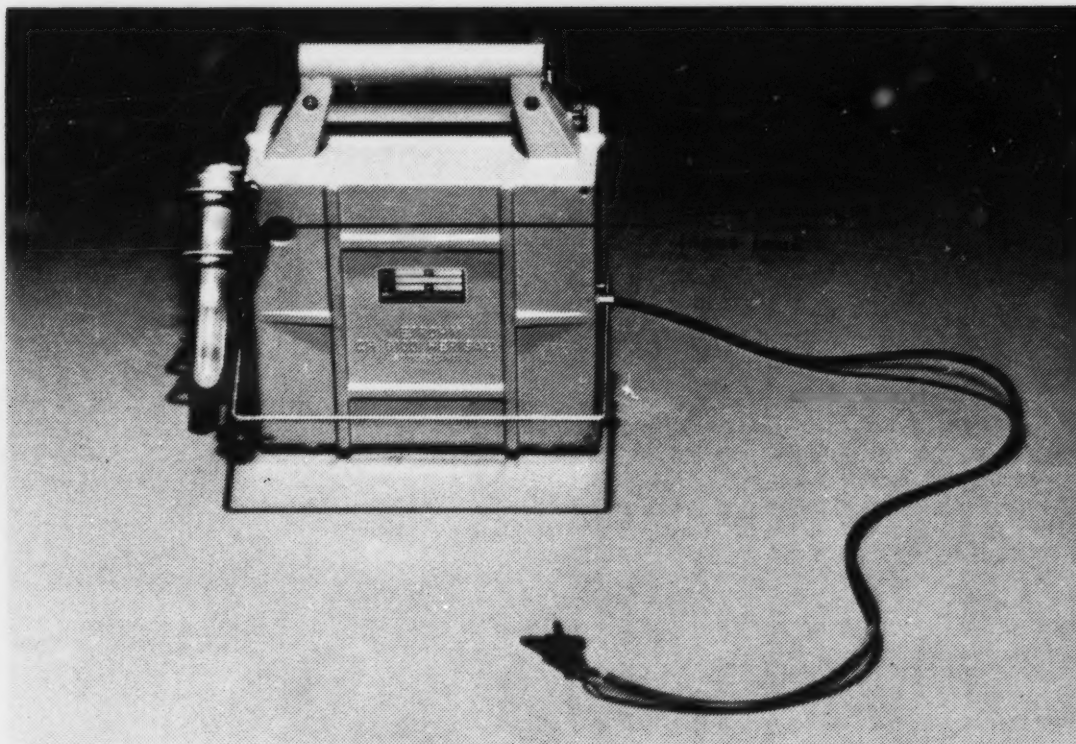


Fig. 1a. E587 CONDUCTOMETER.

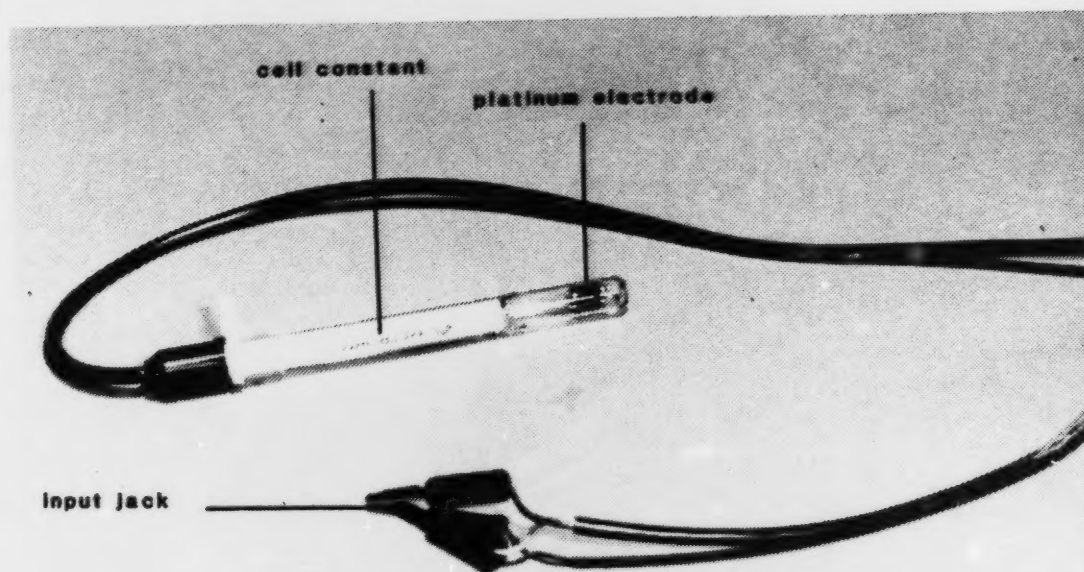


Fig.1b. E587 CONDUCTOMETER PROBE.

7. Rotate the CELL CONSTANT SWITCH until the needle is set to correspond to the conductivity of the KCL standard solution. Remove the probe and rinse well with distilled water.
8. Rotate the SELECTOR SWITCH back to cell const. Obtain a value for the cell constant. If this value is similar to the cell constant marked on the probe, then the probe is considered to be in good operating condition. If the cell constants differ greatly, then the probe requires cleaning.
9. Set the SELECTOR SWITCH to the appropriate measuring range and record the conductivity of the water sample. Rinse the probe with distilled water after each measurement.
10. Fill the storage tubes with distilled water. Be sure to rinse the probe with distilled water before inserting it in the storage tube to prevent a buildup of ions in the storage tube.
11. Report the conductivity in microsiemens/cm at 25°C.

Procedure for YSI Model 33 S-C-T Conductivity Meter. (See Figure 2)

Calibration.

1. To calibrate, turn the conductivity meter off and set the needle to zero with the ZERO ADJUST SCREW below the display window on the conductivity meter (Figure 3).
2. Turn the METER SWITCH to red line and adjust the RED LINE CONTROL so the needle points to the red line on the scale. If the meter will not reach the red line replace the battery.
3. Remove the PROBE from the storage flask of distilled water and dry it with a paper towel.
4. Immerse the PROBE in standard KCl solution and calibrate the meter by adjusting the ZERO ADJUST SCREW.
5. Return the PROBE to the storage flask.

NOTE The meter should be calibrated daily. If the probe becomes dirty and the reading does not stabilize readily, clean the probe with spray foam bathroom cleaner. Allow 15 minutes for foam to penetrate into the probe. Rinse probe well with distilled water before use.

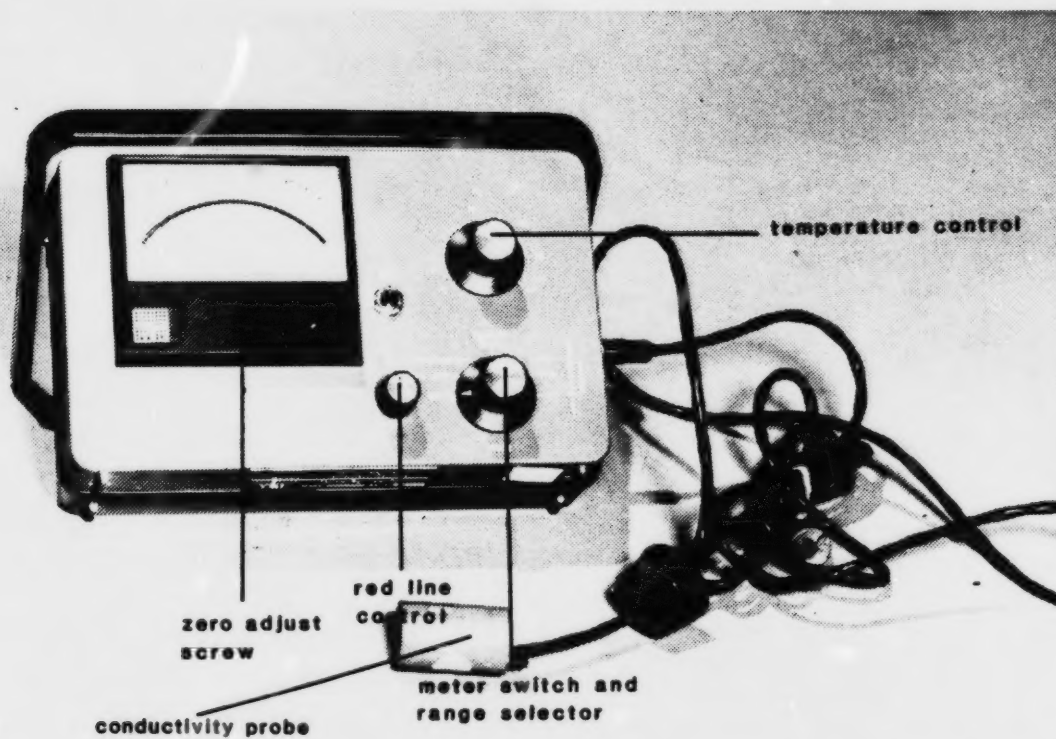


Fig. 2. YSI MODEL 33 SCT CONDUCTIVITY METER.

Procedure.

1. Mix the sample thoroughly.
2. Remove the PROBE from the storage flask of distilled water. Rinse the PROBE with distilled water before immersing it in the sample.
3. Turn the RANGE SELECTOR to red line and adjust the RED LINE CONTROL so that the needle points to the red line on the scale.
4. Turn the RANGE SELECTOR to temperature and adjust the TEMP control on the meter to the temperature reading.
5. Turn the RANGE SELECTOR to x1 scale and read the conductivity.
6. Return the PROBE to the storage flask of distilled water

4.6.3 pH Measurement

Introduction. The pH is the logarithm of the reciprocal of the hydrogen ion concentration (more precisely, of the hydrogen ion activity) in moles per litre. The practical pH scale extends from 0 (acidic) to 14.0 (alkaline). The pH of most natural waters falls between 4.0 and 9.0. The neutral point of pH is 7.0, and most natural water is slightly basic due to the presence of carbonate and bicarbonate. Industrial waters may be strongly acidic or basic.

These procedures are designed for the Metrohm Model 582 pH meter or the Corning pH meter. If another model is used it will be necessary to read and follow the instruction manual to set up the instrument. The procedure for collecting the sample and recording the value obtained should be the same. Common sense and good field procedure should suffice to obtain comparable data.

Quality Control. The following factors must be considered and followed to ensure that the work done is of acceptable quality.

1. Use a plastic protector for glass electrodes.
2. The Calomel reference electrode that requires saturated

KCl solution as a filling should contain a few KCl crystals. The level of the KCl solution should be checked daily.

3. Store the electrodes in a 3.0 M KCl buffer solution when not in use.

4. The electrodes must not be exposed to cold (below 0°C). Exposure to freezing temperatures will result in the freezing of the electrolyte and subsequent destruction of the glass wall.

5. The electrodes must be kept clean of any buildup on the exterior, but care must be taken to avoid scratching the electrode. Use only a wet tissue or similar soft, damp material to clean electrodes. If the electrode becomes scratched it must be replaced.

6. The electrode must be kept filled with 3.0 M KCl solution to the top of the filling hole. Do not seal the filling hole.

7. The probe should be cleaned each week by soaking the probe overnight in a 3.0 N KCl solution.

8. An accumulation of impurity precipitates and the precipitation of silver chloride (AgCl) is not important since they are present between refillings.

9. It is important to prevent water from getting into the electrode when taking measurements, so the electrode should never be immersed below the filling hole. If this happens the electrode must be emptied and refilled. The proper depth of immersion of the electrode below the water surface is approximately five centimetres.

10. Whenever possible use disposable plastic beakers for measurements to prevent scratching of the electrode. This is also a good way to avoid contamination of the samples.

11. Use EPA standard pH buffer for calibration of the equipment.

12. Keep the pH buffer solution sealed for reuse.

Occasionally (at least weekly) check the buffer solution against the stock pH buffer solution to ensure that there has not been a change in the buffer solution pH due to dilution.

Equipment List.

pH meter and probe

pH buffer

100 ml beakers

Procedure for Metrohm Model 588 pH Meter. (See Figure 3)

1. Check that the battery is fully charged. Do not use the equipment unless the battery is fully charged. It requires 36 hours to fully recharge the battery.
2. Prepare a beaker of pH 7.0 buffer and another of pH 10.0. Allow the buffer solutions and water samples to equilibrate in a constant-temperature water bath to 25C.
3. Set the TEMPERATURE COMPENSATION POTENTIOMETER to the temperature of the pH buffer solutions (25°C).
4. Set the SLOPE ADAPTION POTENTIOMETER to 100 %.
5. Insert the electrode (probe) in the pH 7.0 buffer solution. Start stirring and wait until the meter needle stabilizes. Set the COUNTER-VOLTAGE POTENTIOMETER (or u knob) to make the meter read pH 7.0. Rinse the probe with distilled water.
6. Repeat with the pH 10.0 or 4.0 buffer, but do not adjust the COUNTER-VOLTAGE POTENTIOMETER.
7. Adjust the SLOPE ADAPTION POTENTIOMETER to calibrate to pH 10.0 for pH 10.0 buffer and pH 4.0 for pH 4.0 buffer.

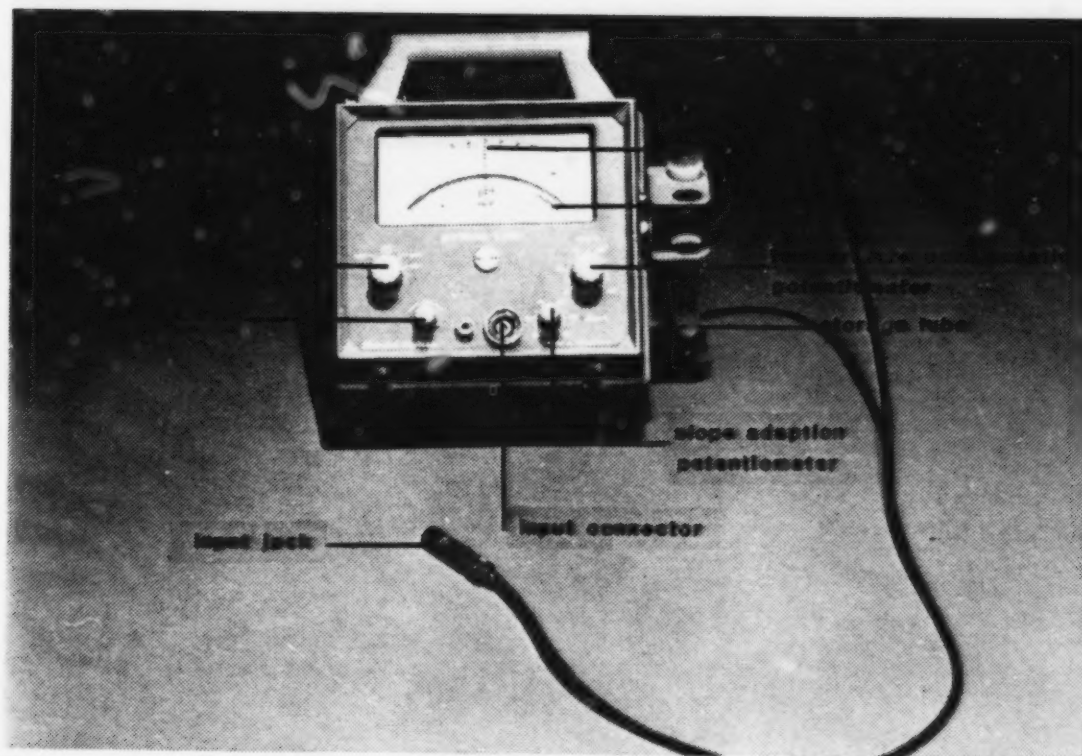


Fig. 3 E588 pH METER.

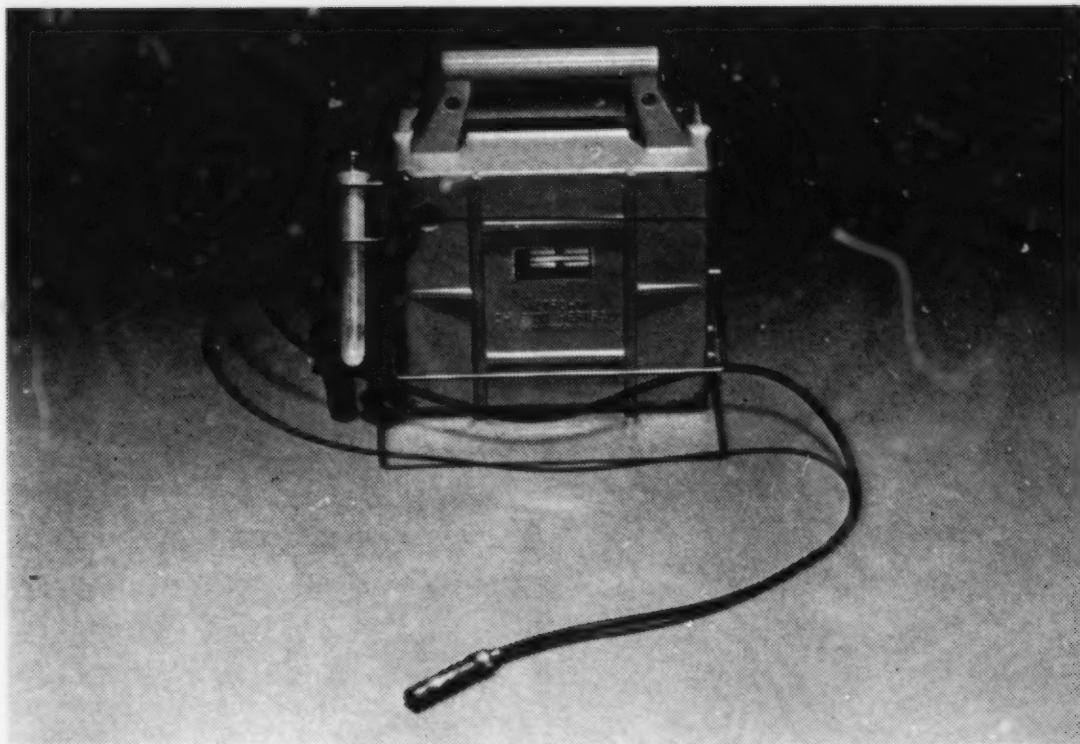


Fig. 3a. E588 pH METER.

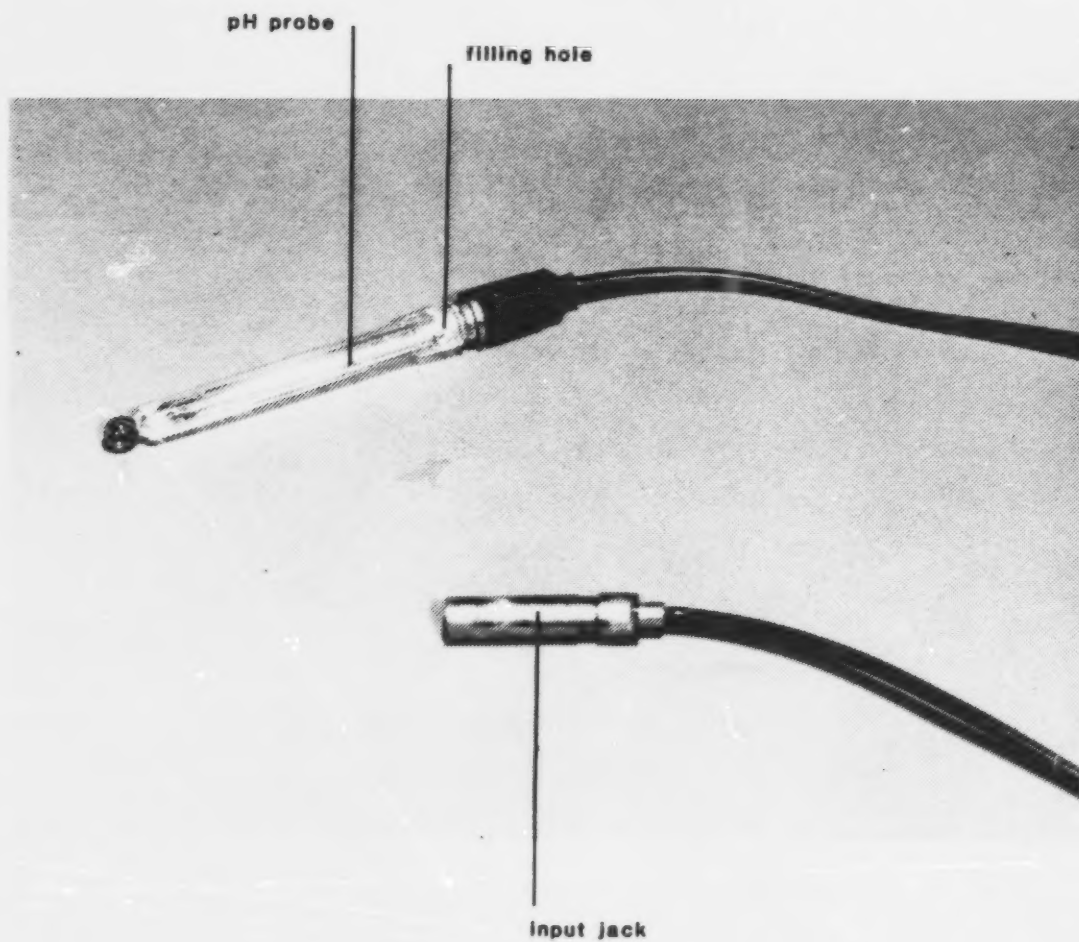


Fig. 3b, E588 pH PROBE.

8. Rinse the electrode with distilled water.
9. Immerse the electrode in the water sample. Do not immerse the electrode below the filling hole, but insert it into the water about five cm.
10. Allow five minutes for the pH reading to stabilize, then record the pH measurement.
11. Shake the electrode gently to remove any water left on it. Rinse the electrode thoroughly with distilled water, and replace the electrode in the storage tube filled with 3.0 M KCL solution.

Procedure for the Corning pH Meter 3D. See Figure 4

1. Turn the POWER SWITCH to the on position.
2. Check the battery condition by pressing the BATTERY TEST switch. If the red light does not come on replace the batteries.
3. Immerse the electrode in pH 7.0 buffer solution and allow the meter display to stabilize.
4. Adjust the TEMP control knob to the temperature of the solution to be measured.
5. Adjust the CALIBRATE knob until the meter displays the pH of the buffer solution (7.0).
6. Remove the electrode from the buffer solution, and rinse with distilled water.
7. Immerse the electrode in the water sample. Allow several minutes for the reading to stabilize, then read the pH from the meter.

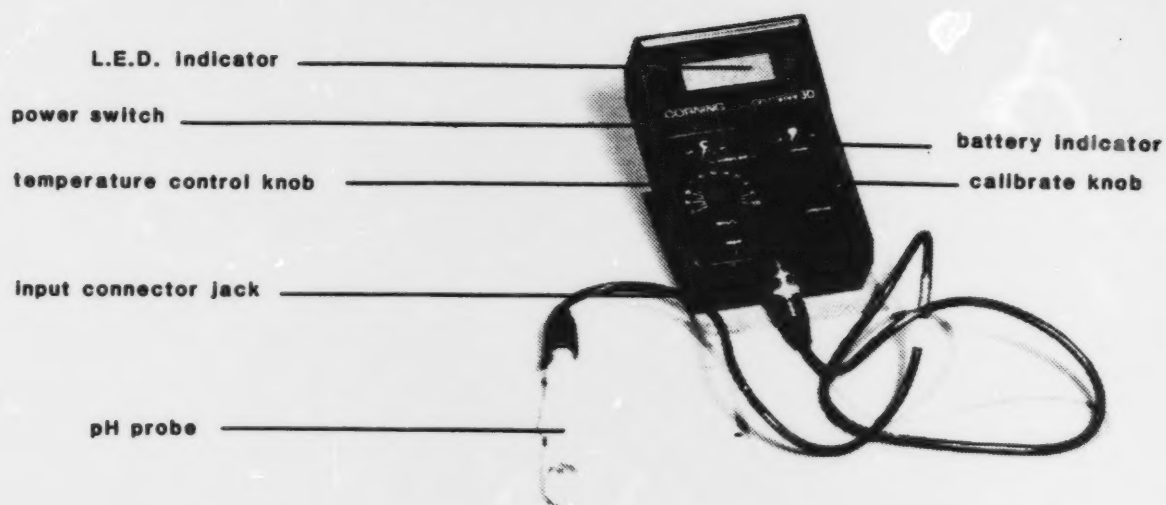


Fig. 4. CORNING pH METER.

8. After taking the measurement rinse the electrode with distilled water and repeat step 7 for up to four sets of measurements. After measuring four sets of samples the meter must be recalibrated.

NOTES

1. If the pH value of the water sample is not within three pH units of the pH of the calibrating buffer, a two-point calibration should be performed as described in the manual.

2. If the meter will not stabilize, rinse the electrode in 10.0 % HCl and check the KCl level inside the electrode. Add more KCl to the electrode if necessary. The procedure is described in the manual.

3. The electrode may be stored temporarily in the buffer solution, but long-term storage should be in the KCl solution.

6.4 Turbidity

Introduction. Turbidity in water is caused by the presence of suspended matter such as clay, algae, silica, bacteria and other finely divided organic and inorganic particles. Particles larger than silt size do not significantly affect the scattering of light.

The particles absorb and scatter some of the light which would be transmitted directly through the water in their absence.

Therefore, the turbidity of the water depends on the amount of material in the water and its ability to scatter transmitted light. The smaller the amount of scattering of light by the material in the water, the greater is the turbidity.

The principle for quantitative determination of turbidity is to pass a beam of light through a water sample of a standard thickness, and then to measure the intensity of the light which leaves the sample at 90° to the path of the incident light beam. The intensity of the light leaving the sample is directly proportional to the turbidity of the water.

Quality Control. Ensure that all glass cuvettes are absolutely clean and free of fingerprints on the cell wall. If any fingerprints are present wipe the cuvette clean with a soft tissue. Throw away any cuvettes with scratches.

Procedure. Figure 5 is a diagram of the instrument control panel.

1. The meter needle is zeroed with the METER ZEROING SCREW while the meter is turned off. Place a cuvette of distilled water (reagent grade, class I) in the turbidimeter.
2. Allow the turbidimeter to warm up for 30 minutes before beginning the procedure.
3. After the turbidimeter has warmed up place the RANGE SELECTOR switch in the 0 - 0.2 FTU (Formazine Turbidity Units) setting. Then the trimmer potentiometer marked 0.2 on the back panel high voltage circuit board is tweaked until the meter reads zero.

This procedure is repeated for each range, with the appropriate trimmer potentiometer being tweaked for each range. The method is described on page 14 of the 2100A manual (see also Figure 4, page 11 of the same manual).

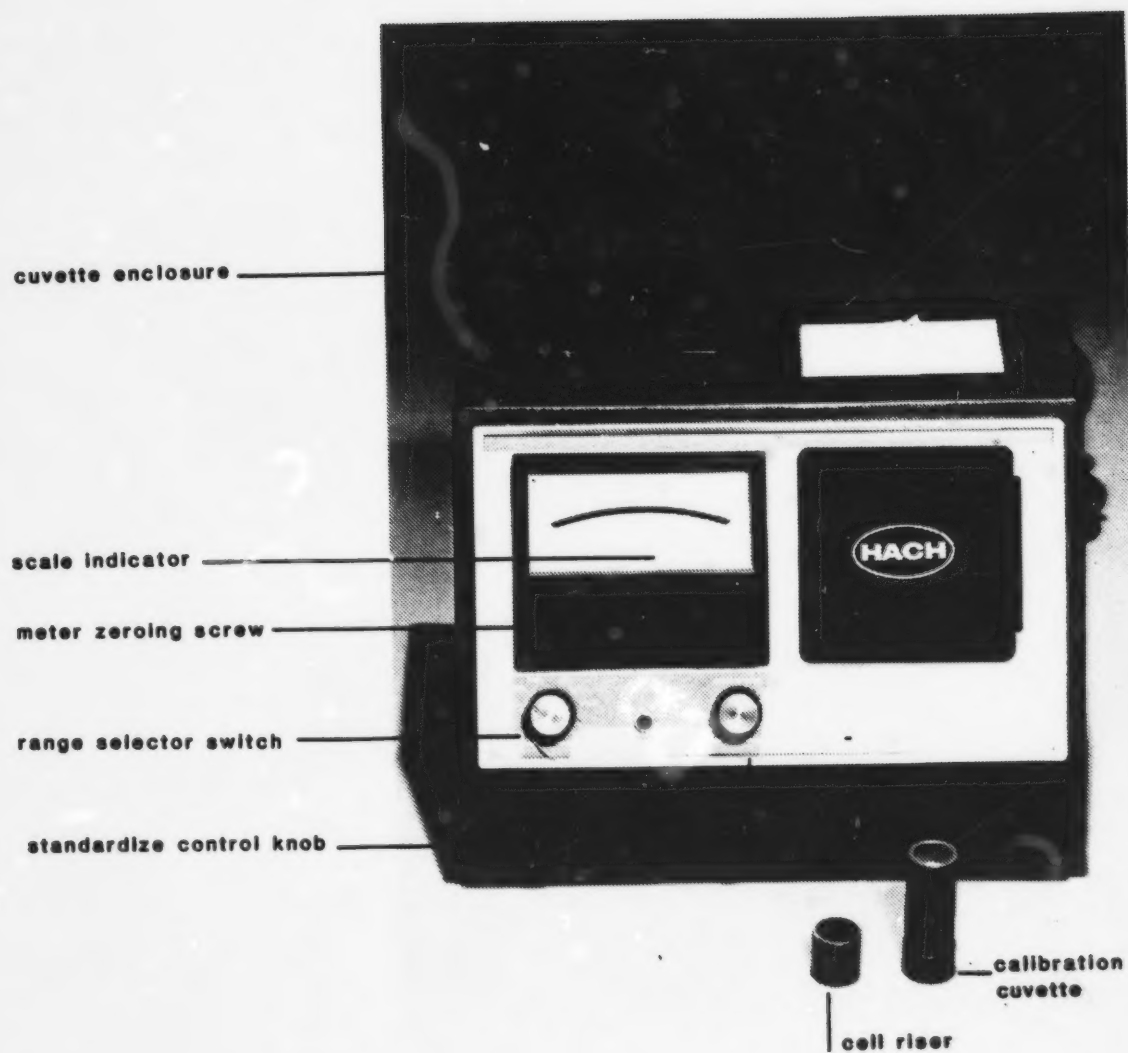


Fig. 5. HACH MODEL 2100 TURBIDIMETER.

This procedure is only necessary once or twice a season, but the zero standard should be checked at least daily, or before each set of measurements.

4. Prepare a stock solution of formazin in accordance with the following instructions.

A. Dissolve 2.50 g of reagent grade hydrazine sulphate ($\text{N}_2\text{H}_4 \cdot \text{H}_2\text{SO}_4$) in 200 ml distilled water in a beaker.

B. In a separate beaker, dissolve 25.00 g of pure hexamethylene tetramine in 200 ml distilled water.

C. Pour the solutions into a 500 ml volumetric flask and dilute to volume with distilled water.

D. Allow the solution to stand for 48 hours at 20 to 22°C before use. During this time, the formazine suspension will develop.

E. The formazine may be stored in a capped bottle or stoppered volumetric flask.

F. The formazine must be shaken well before it is used.

5. Prepare standards for the turbidimeter with distilled water as follows:

<u>FTU</u>	<u>ml of stock solution diluted to 100 ml water</u>
500	12.5
100	2.5
10	0.25
0	0

NOTE Prepare new standards every day.

6. Pour the standard solution closest to the observed turbidity of the water sample in a clean glass cuvette. Place the standards into the cell compartment and adjust the STANDARDIZE CONTROL knob to the standard solution FTU.

NOTE If the measurement is above 10 FTU you must have one riser in the cell compartment.

7. Re-zero the meter with two riser cells inside the compartment.

8. Shake the water sample until the suspended sediment is thoroughly mixed. Allow only one minute for sand particles to settle. Immediately pour the suspended sediment solution into a glass cuvette, filling the cuvette to within one centimeter from the top of the cuvette. Place the cuvette

in the turbidimeter compartment and read the scale immediately.

9. Record the measurement on a data sheet.

10. Rinse all the glassware with distilled water before using it again.

11. Samples with turbidity levels greater than 50 JTU should be subsampled. Shake sample bottle well and allow the sediment to settle for one minute. Pipette a two mL sample from the bottle and mix well with 18 mL distilled water or pipette a 5 mL sample and mix with 20 mL distilled water. Multiply reading by a factor of 10 or 5 respectively to obtain a true value.

6.5 Suspended Solids (Total Non-Filterable Residue)

The suspended solids in a water sample are also known as the total non-filterable residue because the standard determination is based upon determination of the material which is retained by a filter paper during filtration of the sample.

The following is the standard filtration procedure to obtain the weight by volume of total suspended solids in a water sample.

1. Label aluminium weighing trays, using a pen or a dissecting probe, with numbers adequate to have one for each sample.
2. Place a Whatman 934AH glass microfibre filter paper (4.25 cm diameter) in a filtration funnel inserted in a vacuum filtration flask. One filter paper will be needed for each of the samples.
3. Pour 100 mL of distilled water through the filter paper, making sure that the entire filter paper is wetted, and turn on the vacuum until the water has been drawn through the filter paper. Discard the filtered distilled water.

4. Place the wetted filter paper in an aluminum pan and then into a drying oven set at 105°C for one hour. Allow the filter paper to cool for 20 minutes before weighing.
5. Weigh the filter papers and their aluminium weighing trays to the nearest 0.0001 g and record the weights on a lab data sheet. Make sure that the weight of each filter can be identified for later calculations. This weight is called the "tare" or "tare weight" in the calculations.
6. The filter papers if not used immediately should then be stored in a desicator for later use. It is important that they do not accumulate any dust, moisture or any other foreign material during storage.
7. Shake the water sample thoroughly and pour the entire sample into a graduated cylinder. Cap and retain the sample bottle for later rinsing.
8. Record the total volume of the sample in litres to three significant figures.
9. Place a pre-weighed filter paper in a clean filtration funnel. Attach the filtration funnel to a vacuum flask. Turn on the vacuum pump and pour the water sample into the filtration flask.

10. Rinse the graduated cylinder and sample bottle several times with distilled water to ensure all sediment is caught in the filter.

11. Rinse the filtration funnel with distilled water to ensure that no sediment is adhering to the funnel. For quantitative determination, all of the sediment must be on the filter paper.

12. Remove the filter paper from the funnel and place it back onto the original aluminium weighing tray.

13. Place the aluminium weighing tray and filter paper in a drying oven and dry for two hour at 105°C.

14. Allow to cool for 20 minutes before weighing.

15. Weigh the filter papers with their aluminium weighing trays to the nearest 0.0001 g.

16. Subtract the tare weight from the weight of the filter paper, aluminium tray and sediment sample.

17. Calculate the total non-filterable residue (suspended solids) in mg/L by multiplying the weight of the sediment sample (found in step 16) by 1 000, and then dividing it by the sample volume recorded in step 8.

18. Samples that were subsampled require use of a large cone funnel and filter paper.

6.6 Total and Phenolphthalein Alkalinity

Introduction. The alkalinity of water is defined as the capacity of that water to accept protons. Soluble metallic bicarbonates, carbonates and hydroxides are responsible for the alkalinity of natural, industrial or treated water.

The phenolphthalein alkalinity is a measure of the alkalinity fraction which is contributed by the hydroxide and half the carbonate.

The total alkalinity is the contribution from to all bicarbonates, carbonates and hydroxides present in the water sample.

These methods can be used to measure the vulnerability of a natural water body to degradation by acid rain.

The phenolphthalein alkalinity and the total alkalinity are determined by potentiometric titration of an unfiltered sample aliquot with a standard solution of strong acid to pH 8.3 and 4.5 respectively. They are expressed as mg/L CaCO_3 .

Quality Control. Analysis of samples should be started as soon as possible after the samples are collected to prevent the loss of any dissolved gasses. Do not shake or mix samples.

Reagents.

1. Standard sodium carbonate solution (0.0200 N). Oven dry about 1.5 g of anhydrous sodium carbonate (Na_2CO_3) at 140°C for 24 hours. Dissolve 1.060 g of the oven dried anhydrous sodium carbonate in one litre of CO_2 -free distilled water.

2. Stock sulphuric acid (0.1 M). Dilute 200 mL of concentrated sulphuric acid (6 M) to one litre with distilled water. Add the water to the acid slowly to prevent splattering caused by the buildup of heat.

3. Standard sulphuric acid (0.0200 M). Dilute 200 ml of the 0.1 N stock sulphuric acid solution to one litre with CO_2 -free distilled water. Standardize with 0.02 M Na_2CO_3 solution (prepared by diluting 10.0 mL of the standard .0200 N Na_2CO_3 solution to 100 mL with CO_2 -free distilled water) by titrating with 0.02 M sulphuric acid. The required normality is given by:

$$M(\text{acid}) = \frac{0.0200 \times 10}{\text{ml acid}}$$

4. Buffers of pH 4.0, 7.0 and 10.0.

Procedure. Determine the total and phenolphthalein alkalinity as follows.

1. Standardize the pH meter using two buffers (pH 7.0 and 4.0).
2. Pipette 10.0 mL of 0.02 M Na_2CO_3 into a 100 mL volumetric flask and dilute to 100 mL with distilled water. Pour the sample into a 250 mL beaker.
3. Record the initial pH of the Na_2CO_3 in the beaker.
4. Record the initial volume of H_2SO_4 (referred to as V_1) before the titration begins. Titrate the sample with 0.02 N H_2SO_4 until the pH is at 4.5. Record the amount of H_2SO_4 used (this is referred to as V_2). Then continue the titration until the pH is 4.2. Again record the amount of H_2SO_4 used. This is referred to as V_3 .
5. Repeat step 4 with 100 mL water samples.
6. Run duplicates and spikes with the samples in accordance with the quality control programs.

Calculations.

1. Calculate the normality of the reagent sulphuric acid, using the data from duplicate standard solution aliquots and taking the average for the normality of the acid to use in calculating the alkalinity of the water samples. The formula for calculating the normality of the reagent acid is:

$$[V_2 - V_1] - [V_3 - V_2]$$

Where: V_1 = initial volume of acid (i.e. 0),
 V_2 = ml to reach pH 4.5, and
 V_3 = ml to reach pH 4.2.

Two titrations of the reagent acid are done, the average of the two titrations is taken, and this average value is used to calculate the normality of the reagent sulphuric acid as shown in the following example:

Titration No. 1.

$$\begin{aligned} & [V_2 - V_1] - [V_3 - V_2], \text{ or using} \\ & \text{numbers,} \\ & [10.50 - 0.0] - [10.67 - 10.50] \\ & = 10.33. \end{aligned}$$

Titration No. 2.

$$\begin{aligned} & [21.40 - 11.00] - [21.58 - 21.40] \\ & = 10.22. \end{aligned}$$

Then:

$$\begin{aligned} \text{average volume} &= \frac{\text{Titration No. 1} + \text{Titration No. 2}}{2} \\ &= \frac{10.33 + 10.22}{2} \\ &= 10.27 \end{aligned}$$

Therefore:

$$\begin{aligned} \text{Normality of acid (M)} &= \frac{0.02 \times 10}{10.27} \\ &= 0.195 \text{ M.} \end{aligned}$$

2. The total alkalinity is calculated by

$$\text{mg/L CaCO}_3 = \frac{50,000 \times M \times V_2}{\text{Sample Volume}}$$

Where: M is the normality of the reagent acid calculated in step 1, and

V_2 = mL of acid to reach pH 4.5.

3. If the pH of the water sample is greater than 8.3, repeat the lab procedure until a pH of 8.3 is reached.

The phenolphthalein alkalinity is calculated by

$$\text{mg/L CaCO}_3 = \frac{50,000 \times M \times V_1}{\text{Sample Volume}}$$

Where: V_1 = mL of acid to reach pH 8.3.

4. To calculate hydroxide, carbonate and bicarbonate use the relationships in Table 1.

TABLE 1
ALKALINITY RELATIONSHIPS

Result of Titration	Hydroxide as OH^-	Carbonate as $\text{CO}_3^{=}$	Bicarbonate as HCO_3^-
$P = 0$	0	0	$1.22 \times T$
$P < 1/2 T$	0	$1.2 \times P$	$1.22(T-2P)$
$P = 1/2 T$	0	$1.2 \times P$	0
$P > 1/2 T$	$0.34(2P-T)$	$1.2(T-P)$	0
$P = T$	0.34	0	0

Where : P = Phenolphthalein alkalinity, and
 T = Total alkalinity.

6.7 Dissolved Calcium

Introduction.

Most natural waters have a significant amount of calcium. The presence of calcium in ground and surface waters results from passage through or over deposits of limestone, dolomite, gypsum and calcareous shale or sandstone.

This procedure is intended to provide a quantitative measure of the amount of dissolved calcium in the water sample.

Preparation of Reagents. The following reagents need to be prepared in advance of the analysis of samples as described in the procedures.

1. 10.0 M Sodium Hydroxide. Dissolve 400 g of sodium hydroxide (NaOH) pellets in distilled water. Add a small amount of distilled water to the pellets, being careful of the intense heat generated. After the solution has cooled completely, dilute to one litre with distilled water.

CAUTION This solution is HIGHLY CAUSTIC. Appropriate safety equipment is required when handling the solution.

2. 1.0 M Sodium Hydroxide. Dilute 10.0 mL of 10.0 M NaOH with distilled water to 100 mL, using a volumetric flask. Store this solution in a plastic container because NaOH etches glass.

3. Standard Calcium solution (1 000 mg/L of CaCO₃).

Prepare a solution of calcium carbonate (CaCO₃) as follows: Weigh 1.000 g of anhydrous calcium carbonate powder which has been oven dried at 105°C for 24 hours. Place the calcium carbonate powder into a beaker and add 100 mL of distilled water. Then add 10 mL of HCl to dissolve the calcium carbonate completely.

Using a pipette, add 5 mL of the 10.0 M NaOH to the calcium carbonate solution.

Continue adding 1.0 M NaOH until the pH reaches 4.5. Pour this solution into a 1 L volumetric flask.

Rinse the beaker thoroughly to ensure that all the calcium is placed in the volumetric flask. Dilute to 1 L to complete the preparation of the standard calcium solution.

4. 2.0 M Sodium Hydroxide solution: Place 20 mL of the 10.0 M sodium hydroxide solution in a 100 mL volumetric flask and dilute to 100 mL with distilled water.

5. EDTA titrant (0.01 M): Dissolve 3.723 g EDTA in distilled water and dilute to 1 L. In order to standardize this solution it is necessary to titrate samples of the standard calcium solution as follows:

A. Place 10.0 mL of the standard calcium solution in a 50 mL volumetric flask and dilute to 50 mL with distilled water. Transfer this to a 100 mL beaker.

B. Add 2.0 mL of 2 M NaOH to the 50 mL calcium solution prepared in step "A" to give a pH of between 12 and 13. Stir well. If a pH of between 12 and 13 is not obtained, add additional 2 M NaOH until the pH is between 12 and 13.

C. Add 0.1 g of Calver II powder and stir well. The color should be purplish-red.

D. Titrate with the standard EDTA titrant until the purplish-red tinge disappears. Note the number of

millilitres of EDTA standard used. This is the volume of EDTA standard required to neutralize 10 mL of the standard calcium solution, and will be used to calculate the amount of calcium in the samples.

Procedure.

1. Filter 50 mL of a water sample through a 40 micron filter and place it in a 100 ml beaker.
- 2 Add 2.0 mL 2M NaOH (dilute 20 mL of 10M NaOH with distilled water in 100 mL volumetric flask) to give a pH of 12-13. Stir well. If the pH of 12 to 13 is not attained add additional 2 N NaOH until the sample pH is between 12 and 13.
3. Add 0.1 g of Calver II powder and stir well. The color should be purplish-red.
4. Titrate the sample with standard EDTA titrant until the purplish-red tinge disappears. Note the number of millilitres of EDTA used.

Calculations. The milligrams per litre (mg/L) of calcium in the sample are calculated as follows.

$$1. \quad \text{mg/L Ca} = \frac{(A \times B \times 400.0)}{(\text{ml of water sample})}$$

Where: A = mL of EDTA to titrate the water sample.

B = mg CaCO_3 equivalent to 1.00 EDTA titrant

$$= \frac{(\text{vol. of standard Ca solution})}{(\text{vol. of EDTA to titrate standard Ca solution})}$$

$$= \frac{10 \text{ mL}}{\text{vol. of EDTA to titrate standard Ca solution}}$$

6.8 Dissolved Oxygen

Refer to Volume 3, Section 6.5 for standardization procedure before proceeding.

Mix the samples by inverting the bottle a few times. When the precipitate has settled sufficiently (to approximately half the bottle volume), add one mL of concentrated sulphuric acid to leave a clear supernatant above the manganese hydroxide floc. Replace the stopper and mix the contents by inverting the bottle several times until the mixture has completely dissolved.

Titrate 200 mL of the original sample with 0.025 M sodium thiosulphate solution to a pale straw color. Then add four drops of the starch solution and continue the titration to the first disappearance of the blue color.

Calculations. The relation from titration is that one millilitre of the 0.025 M sodium thiosulphate solution is equivalent to one milligram of dissolved oxygen per litre of water sample.

To obtain the results in milligrams of oxygen gas per litre corrected to 0°C, multiply the milligrams of dissolved oxygen per litre by 0.70.

7. COLLECTION AND PRESERVATION OF WATER SAMPLES FOR ALBERTA ENVIRONMENTAL CENTRE, VEGREVILLE

7.1 Introduction

There are several types of water quality analyses that require that the sample be collected and sent to the Alberta Environmental Centre, Vegreville. This section describes the procedure for collecting, preserving, storing and shipping samples.

7.2 Quality Control

Do not expose the sample bottles to acetone or ethanol fumes.

Do not rinse the bottle for the NFR sample with stream water before taking the sample. All the others are rinsed with stream water before collecting the sample.

Do not rinse any of the bottles with distilled water, acetone or ethanol before taking the samples.

Keep caps on the bottles until the sample is actually taken, then replace the caps immediately to reduce the chance of sample contamination.

7.3 Procedure

Water samples for analysis will be taken from each station twice monthly during the spring freshet and monthly during base flow.

1. Five bottles are needed for a standard analysis.
 - 1 - 500 ml bottle marked "Routine"
 - 1 - 125 ml bottle marked "G2"
 - 1 - 125 ml bottle marked "LLN"
 - 1 - 125 ml bottle marked "Carbon"
 - 1 - 125 ml bottle marked "NFR"
2. Label each bottle with the date, time, station location and type of analysis required. Except for the "NFR" bottle, rinse the sample bottle twice with stream water and fill it to the top. Fill out an Environment Alberta "Chemical Analysis Request" form (Figure 4.7) completely.
3. For the bottles marked "G2", take the bottle back to the laboratory for preservation. Add one glass ampule (labelled with a brown dot) of H_2SO_4 into each bottle. Be careful to avoid spillage and contamination of any other bottles with acid.
4. For the bottles marked "LLN", filter the sample using a Sartorius membrane filter paper. Do not use Whatman 934 AH

CHEMICAL ANALYSIS REQUEST				Results to:			
Bag 4000 Vegreville, Alberta T0B 4L0 (Telephone 632-6761 Ext. 255)				Name (Print) _____			
				Address _____			
				Phone _____			
				PROJECT NO. 			
LAB SAMPLE NO. 		SAMPLED BY		DESCRIPTION			
Source _____		Name _____		Grab ☒			
Location _____		Phone _____		Composite _____			
		Date _____		Hours _____			
		Time _____ Flow _____		Depth _____			
ROUTINE		METALS		EFFLUENTS			
☒ 2 pH ☒ 3 Conductivity ☒ 16 HCO ₃ ☒ 15 CO ₃ ☒ 68 T-Alkalinity ☒ 6 Na ☒ 7 K ☒ 12 Cl ☒ 9 SiO ₂ ☒ 4 Ca ☒ 5 Mg ☒ 67 T-Hardness ☒ 13 SO ₄ ☒ 14 F ☒ 10 (NO ₃ +NO ₂)-N ☒ 11 NO ₂ -N ☒ 8 Fe ☒ 69 TDS (Calc)		☐ 49 Cd ☐ 45 Cu ☐ 47 Ni ☐ 44 Co ☐ 52 Zn ☐ 59 Al ☐ 53 Be ☐ 46 Mn ☐ 50 Cr ☐ 55 V ☐ 58 Mo ☐ 51 Pb ☐ 40 As ☐ 41 Se ☐ 54 Ag ☐ 56 Ba ☐ 38 Cr ⁶ ☐ 42 Hg		☐ 18 BOD ☐ 93 BOD (Filt) ☐ 71,72,73 Color ☐ 30 MBAS ☐ 33 Tann&Lign ☐ 21 Odor ☐ 27 Turbidity ☒ 25 NFR ☐ 24 FR ☐ 23 TR ☐ 17 COD ☐ 20 Oil & Grease ☐ 29 Phenols ☐ 35 Cyanide ☐ 36 Sulfide		☒ 31 TP ☒ 32 TKN ☐ 66 TON ☐ 88 TP(Diss) ☐ 90 TKN(Diss) ☐ 89 TP(Part) ☐ 91 TKN(Part) ☐ 63 TN(Part) ☒ 85 PO ₄ -P ☒ 86 (NO ₂ +NO ₃)-N ☒ 87 NO ₂ -N ☒ 28 NH ₃ -N COMMENTS _____	
				CARBONS			
				☒ 39 DOC ☒ 77 DIC ☒ 76 TC(Pa) ☐ ☐ 60Halof			

Please see reverse side for instructions, sample volume, and sample preservation requirements

Fig. 8. CHEMICAL ANALYSIS REQUEST.

glass microfibre filter paper.

5. Wash the outside of all bottles with distilled water after they have been sealed to avoid contamination.

6. Keep the samples refrigerated at 4°C, and in the dark, until delivery to Vegreville. Use ice packs to keep the samples cool during transport. Delay of longer than seven days in storage compromises the results.

GENERAL REFERENCES

American Public Health Association, American Water Wastes Association, and Water Pollution Control Federation, 1980. Standard Methods for the Examination of Water and Wastewater. 15th edition.¹ American Public Health Association, New York. 874p.

Gray, D. M. and Male, D. H. Editors. 1981. Handbook of Snow: Principles, Processes, Management and Use. Pergamon Press.

Herschy, R., 1970 The Magnitude of Errors at Flow Measurement Stations. Vol. 1. Proceedings, Symposium on Hydrometry, Koblenz. Sept. 1970. pp. 109- 131. IAHS Paris Publication No. 89.

International Organization for Standardization. 1981. Liquid Flow Measurement in Open Channels - Part 1: Establishment and Operation of a Gauging Station. ISO 1100/1-1981 (E).

United States Department of the Interior, Geology Survey. 1977. National Handbook of Recommended Methods for Water-Data Acquisition. Reston, V.A.

¹ A 16th Edition is now available